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THE PLANT DISEASE REPORTER

Issued By

PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

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Volume 40 Number 8

August 15, 1956

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch — Plant Industry Station, Beltsville, Maryland
Volume 40 — Number 8

August 15, 1956

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THE FAO PLANT PROTECTION BULLETIN: A REPORT TO OUR COOPERATORS

Paul R. Miller

At intervals in the REPORTER we have called attention to our responsibility as official correspondents in this country of the United Nations Food and Agriculture Organization PLANT PROTECTION BULLETIN. Herewith is a brief explanation of our procedure in meeting this responsibility.

The FAO PLANT PROTECTION BULLETIN is now in its fourth volume. It is issued monthly in English, French, and Spanish, "as a medium for the dissemination of information received by the World Reporting Service on Plant Diseases and Pests, established in accordance with the provisions of the International Plant Protection Convention, 1951. It publishes reports on the occurrence, outbreak and control of pests and diseases of plants and plant products of economic significance and related topics, with special reference to current information."

When the Department of Agriculture agreed to cooperate in the World Reporting Service on Plant Diseases and Pests, Plant Disease Epidemics (then known as the Plant Disease Survey) was designated by the Department as correlating agency for United States information on plant diseases. Obviously we could not possibly carry out this assignment without help from plant pathologists throughout the country. To be sure that pathologists were fully informed about the aims of the World Reporting Service and the nature of our connection with it we gave complete accounts in the mimeographed Warning Letter, and shorter notices in the REPORTER.

Ever since we were assigned this task we have sent a monthly report to the BULLETIN. Because the PLANT DISEASE REPORTER is so closely identified with Plant Disease Epidemics we have felt free to draw on it for source material until we could establish a constant and adequate supply of reports destined especially for the BULLETIN. At first we proceeded on the assumption that our explanation in the REPORTER constituted sufficient request for permission to use the individual articles for this purpose; also, since the reports were obviously compilations and would be recognized as such, at first we did not cite original authors' names. Now, however, to prevent any sort of misunderstanding, when we notify an author that his article is accepted for the REPORTER we ask him to fill out the following form (naturally this applies only to authors in the United States since reports from other countries are not our concern):

> Appropriate articles furnish the basis for reports prepared each month by Plant Disease Epidemics for the journals "Agricultural Chemicals" and the FAO "Plant Protection Bulletin." The information may be summarized, combined with other reports, or used with minor changes. Credit will be given the original authors.
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> Check YES or NO on the proper line, detach this portion and return to us at once.
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> _____YES _____NO
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> (Signed)_____

Judging from the response, which is practically all affirmative, our original assumption was entirely justified. Nevertheless, it is best to have approval on record.

Sometimes contributors ask us to let them know beforehand about changes that might be made in an article, or to furnish reprints or copies when it appears. Either request is equivalent to a "NO" answer on the form, because there is no time for correspondence about changes,

and Plant Disease Epidemics does not receive reprints of any report.

Of course not all articles are suitable. Our choice is not a judgment of intrinsic importance but is based on whether content is of some special significance for other parts of the world.

These reports must fit in with all the other deadlines we have to meet, including that for the REPORTER which by itself often almost overwhelms our small staff. This matter of time is the limiting factor in the amount of care that we can give to the preparation of the reports, and is responsible for some inconsistency in our treatment of the material. We simply do not have time for extensive summarizing or rewriting, and frequently use articles essentially as originally presented.

In the BULLETIN the reports are published under the general title "Plant Disease Situation in the United States", by Paul R. Miller, with the footnote: "This report is based upon material submitted by Collaborators of the Plant Disease Epidemics and Identification Section, Agricultural Research Service, United States Department of Agriculture." Two or three reports, unfortunately, were published without the general title and without the footnote.

The BULLETIN has an increasingly important function as an international medium for speedy communication of plant disease and pest news and we believe that pathologists who have not already done so would do well to acquaint themselves with it. Besides reports from the various countries it contains plant quarantine news, notices of meetings, and other material of general interest. As an example, the current number (March) is wholly occupied by a symposium on tristeza disease of citrus, which will be continued in the April issue. The editor is Dr. Lee Ling, Plant Production Branch, Agriculture Division, FAO, Viale delle Terme di Caracalla, Rome, Italy. Subscriptions ($3.00 per year) are handled by Documents Sales Service, FAO, Viale delle Terme di Caracalla, Rome, Italy.

Under the heading "The Listening Post" the journal AGRICULTURAL CHEMICALS publishes news on chemical control of plant diseases and insect pests, with the note "The comments on current plant disease problems are based on observations submitted by collaborators of the Plant Disease Epidemics and Identification Section, Horticultural Crops Research Branch, U. S. Department of Agriculture, Beltsville, Md." For this again we use material from the REPORTER. We believe this feature is well-known and appreciated.

Reports for both journals are part of our official duties. No one receives any outside compensation whatever. Plant Disease Epidemics does obtain copies of both journals, but no reprints.

We believe firmly that we are rendering a real service to plant pathology and that these reports are definitely useful. We also feel that they are not our responsibility only, but an obligation that pathologists in this country have tacitly acknowledged, and in the case of the BULLETIN have definitely assumed through approval of the World Reporting Service by the American Phytopathological Society.

PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION
HORTICULTURAL CROPS RESEARCH BRANCH
AGRICULTURAL RESEARCH SERVICE
PLANT INDUSTRY STATION, BELTSVILLE, MARYLAND

FORMULAS FOR PATHOGRAPHS -- A PROPOSAL FOR A GRAPH FORM NEW TO PHYTOPATHOLOGY

Kenneth H. Garren

ABSTRACT

Pathographs, proposed adaptations of ecological graphs called phytographs, still seem of value to phytopathologists. Phytographs are polygonal graphs. They are now in widespread use in ecology particularly for depicting the results of quantitative surveys. These surveys usually compare species as to their expressions of the fundamental phytosociological characteristics of abundance, frequency, maturity, and basal area. Most plant-disease surveys and many other types of phytopathological research seek to measure and compare the different reactions of species to diseases. "Abundance", "frequency", "maturity", and "severity" are brief descriptive names for comparative phytopathological characteristics which are remarkably similar to the fundamental phytosociological factors. Primary formulas for obtaining numerical expressions of these phytopathological characteristics are proposed.

INTRODUCTION

Historical

In 1950 the writer (1) proposed adapting phytographs to phytopathological use and suggested that the adaptations be known as "pathographs". Phytographs were introduced by Lutz (4) in 1930. The use of polygonal graphs or charts in presenting ecological data became so widespread that a report on their construction and interpretation was published in 1940 (3). At present Oosting (5) and his associates are outstanding in their use of phytographs in ecological publications.[1]

The original proposal on pathographs (1) was based on data obtained in a survey of leader dieback of sweetgum (Liquidambar styraciflua L.) (2). At first the pathographs developed with these data were thought to be excellent. They were so easily interpreted, however, that the formulas used were considered too simple. These formulas did not take into account certain phytosociological factors which might influence the pathogenesis of the disease. Thereafter the writer made a few efforts at refinement of the formulas by attempting to combine phytosociological characteristics with phytopathological factors. The new formulas evolved were so complex that the pathograph concept was almost abandoned.

This past winter the original and simpler formulas were modified in accordance with the inherent differences between annuals and perennials and were used with data from a study of a stem-rot of peanuts (Arachis hypogaea L.). The pathographs produced also were easily interpreted and the interpretations adequately reflected conditions apparent in the field as well as suggested some conditions not apparent in the field. Therefore, the writer now feels that instead of being a deterrent the simplicity which makes the proposed pathographs easily interpreted is their primary recommendation.

The Nature of Phytographs and How They Might Be Adapted

Phytographs consist of a circle with the center as zero and usually with four factors plotted along right-angle radii. The points are connected to make a tetragon. Survey statistics plotted in this manner give tetragons which vary in size, shape, and skew. The characteristics of abundance, frequency, maturity, or size classes, and basal area (5) can be determined by relatively simple phytosociological surveys. Phytographs based upon these characteristics make it possible for the ecologist to visualize easily the comparative positions of species common to two or more communities. A phytograph of this type made from statistics on a dominant species which has crowded out all competition and is found in widespread pure stands will give a perfect square within the circle. Such species are rare and they might be called "perfect species". The first step the writer takes in interpreting phytographs is to consider the departure of the tetragons from the perfect square. Then the shape and the skew of the figures are studied from the viewpoint of determining how each of the four characteristics contributes to the

[1] Prof. H. J. Oosting and Dr. T. Johnson of Duke University reviewed the original manuscript of this article and made suggestions for its revision.

relative importance of the species in the communities surveyed.

Perhaps the non-ecologist will understand these phytosociological characteristics better if he considers that they represent numerical answers to the following simple but fundamental questions about the comparative importance of the dominant species in the area surveyed:

1. ABUNDANCE. How does the species compare numerically with the other species?
2. FREQUENCY. Is the species distributed evenly or unevenly?
3. MATURITY. Is the species invading, fading out, or holding its own?
4. BASAL AREA. What proportion of the available space does the species occupy?

Most plant-disease surveys attempt to compare the responses of a species to a disease with site or locality as the variable. Many other types of phytopathological research have treatment as the variable. The writer has long been impressed with the similarity between the phytosociological characteristics of abundance, frequency, maturity, and basal area and four of the five bases for comparing the variable responses of a species to a disease. These bases may be more understandable if it is considered that here also what is sought are numerical answers to the following simple questions:

1. ABUNDANCE. What percentage of the suscepts are diseased or how many diseased plants are there per unit area?
2. FREQUENCY. Is the disease distributed evenly or is it more prominent in one habitat or area than in another?
3. MATURITY. Does the disease attack one maturity class such as over-mature plants more readily than it attacks any other class?
4. SEVERITY. How much of the total susceptible plant tissue is diseased?

Polygonal charts can be constructed from numerical answers to these questions. They can be interpreted in much the same way phytographs are interpreted. The first step the writer suggests for interpreting a group of pathographs is to consider the comparative departures of the tetragons from the perfect square. After this the shape and skew of the tetragons may be studied from the viewpoint of determining how each of the four characteristics contributes to the relative importance of the disease in each of the treatments or sites. This should give a clear picture of the responses of the species to the treatments or the importance of the disease on the various sites.

The remainder of this report has two chief purposes: to present again the pathograph concept and to present the primary form of formulas which will give numerical answers to the four phytopathological questions listed.

PROCEDURES

Examples of Pathographs for Diseases of Annuals

The data of Table 1 are from a split-plot experiment with plots 960 square feet in area. The experiment was designed to compare the effects of four different treatments on a stem-rot of peanuts. The hosts responded stem by stem to attack by the pathogen of the disease under study; an attacked stem usually merited a classification of "dead". The stand count indicated a remarkably uniform original stand and the growth habits of peanuts with their clusters of stems resulted in a uniformly thick stand of peanuts along the rows. The spread of the pathogen appeared to be within rows rather than between rows.

These values are presented only to give data for construction of sample pathographs. This table should not be considered part of even a preliminary report on the experiment.

The pathographs in Figure 1 are based on data in Table 1. The factors plotted clockwise from 12 o'clock are A, percentage ABUNDANCE of diseased plants; F, percentage FREQUENCY of diseased plants; M, relation of disease to MATURITY of suscepts; S, SEVERITY of disease in terms of percentage of total row inches.

Table 1. Data from a study of a stem-rot of peanuts, Holland, Virginia, summer, 1955.

Treatment number	Original stand count	Number of diseased plants	Plots (of 16) in which disease found	Maturity classes (of 20) diseased	Diseased area in terms of row inches covered by disease	Yield (pounds) for treatment
1	6989	329	15	15	1974	951
2	7178	43	10	9	258	1069
3	7073	223	12	15	1338	1034
4	7130	149	13	14	894	986

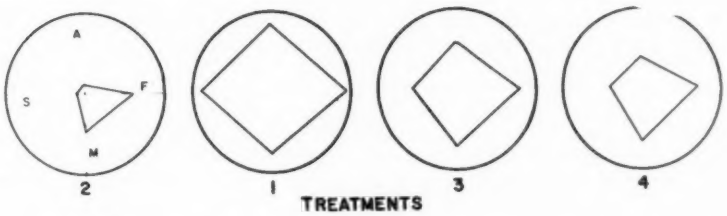

FIGURE 1. Inter-treatment, intra-test pathographs based on data from a stem-rot of peanuts, comparing treatment 1 with treatment 2 and treatment 3 with treatment 4.

The formulas used to derive the statistics from which these graphs were constructed are as follows:

$$A = \frac{\text{Diseased plants in treatment}}{\text{Total diseased plants in test}}^{2} \times 100$$

$$F = \frac{\text{Number of rows in treatment with disease}}{\text{Total rows in treatment}} \times 100$$

$$M = \frac{\text{Weeks when diseased plants found in treatment}}{\text{Total weeks in the observation period}} \times 100$$

$$S = \frac{\text{Total diseased area for treatment}}{\text{Total diseased area for test}} \times 100$$

Examples of Pathographs for Diseases of Non-cultivated Perennials

The data presented in Table 2 are from a survey of leader dieback of sweetgum.. The five maturity classes recognized were based on DBH as follows: Class 1, up to 1 inch; 2, 1 inch to 5 inches; 3, 6 to 10 inches; 4, 11 to 15 inches; 5, 16 inches or more. The total length of the trunk and all branches with diameters of 3 inches or more at the point where they branched-off from the trunk or other branches was determined by standard triangulation techniques and was considered major stem length.

2 Survey plot or some other term could be substituted for treatment; survey or some other term for test; plot for row; etc. to adapt these formulas to various experimental designs.

Table 2. Data from leader dieback of sweetgum, survey of 1951, vicinity of Auburn, Alabama.[a]

Site number	Number of sweetgums in 5 equal-area plots	Diseased sweetgums in 5 equal-area plots	Number of plots in which the disease found	Maturity classes (of 5) diseased	Diseased area in terms of diseased feet per 100-foot major stem length
1	15	11	4	3	25
2	75	41	4	4	24
3	235	100	5	3	26
4	130	38	5	3	17
5	195	53	5	3	15
6	225	27	5	3	8

a The taking of these data was supported by a grant from the Grant-in-Aid Research Program Fund of the Alabama Polytechnic Institute.

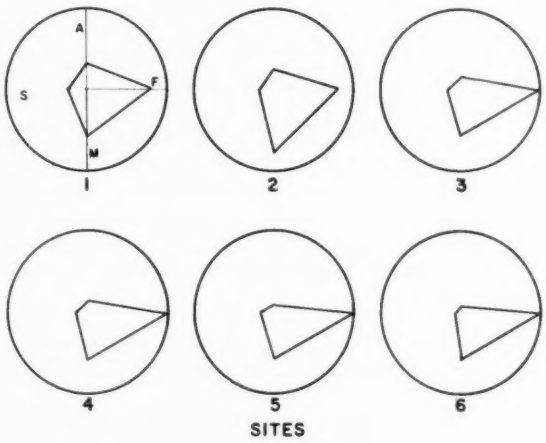

FIGURE 2. Inter-site, intra-survey pathographs based on data from leader dieback of sweetgum, comparing all 6 sites.

The pathographs in Figure 2 are based on data in Table 2. Again the values for the factors ABUNDANCE, FREQUENCY, MATURITY, and SEVERITY are plotted clockwise from 12 o'clock.

For the pathographs of Figure 2 the formulas are as follows:

$$A = \frac{\text{Disease index}^3 \text{ for survey site}}{\text{Total of disease indexes for survey}} \times 100$$

$$F = \frac{\text{Number of plots in survey site with diseased plants}}{\text{Total plots in survey site}} \times 100$$

$$M = \frac{\text{Maturity classes diseased in survey site}}{\text{Number of maturity classes recognized}} \times 100$$

$$S = \frac{\text{Some measure of amount of disease in survey site}}{\text{Total of same measure of amount of disease in survey}} \times 100$$

3. The disease index is derived as follows:

$$100 \times \frac{\text{Diseased individuals for survey site}}{\text{Total individuals of the species in site}}$$

Thus the disease index is the average number of diseased individuals per 100 individuals of the species under study.

Adaptation of Formulas for Diseases of Cultivated Perennials

The formulas for diseases of annuals except the one for "M" may be applied to data from a disease of a cultivated perennial. For diseases in uneven-aged orchards or plantations, however, the formulas for the maturity factor will be identical with the general formula for "M" for diseases of perennials. Diseases in even-aged orchards or plantations will require a special formula as follows:

$$M = \frac{\text{Vigor classes diseased in survey site}}{\text{Number of vigor classes recognized}} \times 100$$

DISCUSSION

The questions listed in the introduction as regarding proposed phytopathological characteristics appear to be fundamental. Surveys to obtain data from which numerical answers may be derived are relatively easy to conduct. A method for presenting these answers in a way which will permit easy consideration of their relation and which will prevent placing undue emphasis on one part of the data or one type of result is needed. The writer believes that the proposed pathographs will meet this need if developed properly.

The formulas are presented as adaptable forms, not as hard and fast recipes. Certainly they are subject to refinement. It is conceivable that adaptation and refinement might produce formulas entirely different from those presented. Consequently, a full and complete discussion of formulas and interpretations would be lengthy and is beyond the scope of the present report. There are, however, a few loose ends which should be gathered together.

The construction of the pathographs for a perennial presented in Figure 2 corresponds a bit more closely to the usual form of phytographs (5, page 63) than does that of the pathographs in Figure 1. In phytographs the nature of the characteristics "abundance" and "area" is such that each is inter-species but intra-community. In the pathograph adaptations (Figure 2) "site" is substituted for "species" and "survey" is substituted for "community". Thus, in both graph forms "abundance" -- and likewise "area" or "severity" -- must total 100 within each community or survey. The pathographs for the disease of the annual crop plant presented in Figure 1 are different from standard phytographs in that the comparisons for pathographs are between treatments while those for phytographs are between communities or sites. In Figure 1 "abundance" and "area" are inter-treatment characteristics, but they are also intra-comparison characteristics.

In all cases, however, the characteristics of "frequency" and "maturity" are such that the observation within any given graph may be anywhere from 1 to 100. Zero means no observations for the sampling area; hence no graph. "Frequency" and "maturity" are intra-species characteristics in phytographs, but in pathographs they may be either intra-treatment characteristics, as shown in Figure 1, or intra-site characteristics, as shown in Figure 2.

The characteristic of "abundance" is determined easily for a disease of an even-spaced crop plant such as that in a row or an orchard. Disease abundance of a disease of a wild plant in a natural stand, however, is undoubtedly influenced by phytosociological abundance. It would also be quite misleading to determine disease abundance on a "per survey" basis. Therefore, the pathograph abundances of Figure 2 were determined on a "per quantity" of suscepts basis; 100 was chosen as the simplest possible quantity unit for the disease-index formula.

When maturity classes for perennials in a natural stand are expressed in terms of DBH or some other equally easily obtained measure the maturity classes should be quite clear and not subject to varying interpretations. If -- as suggested for an even-aged orchard or plantation -- vigor classes are used, extreme care may have to be exercised in delimiting and describing the classes so that they may not be subject to varying interpretations.

For some diseases the characteristic of "severity" is not as clearcut as in diebacks and top-killing diseases such as those used as examples herein. More elaborate formulas may have to be devised for "severity" in pathographs for such diseases as leafspots, foliar viroses, those caused by nematode attacks on roots, etc.

In this connection it should be noted that effect on yield may sometimes be an aspect of "severity" of disease. The fifth basis of plant disease surveys is, "To what extent does the disease affect yield?" One of the main advantages of the pathograph is its simplicity; thus, no consideration has been given to adding a radius for yield. The possibility of determining "severity" in terms of depression of yield has been explored, however, and no means by which depression of yield may be expressed in a form which will fit into the intra-comparison (or intra-survey) nature of "severity" has been found.

The data in Table 1 are from 1 year's work and no definite conclusions as to the efficacy of treatments should be drawn from the pathographs of Figure 1. These data were used because they appear typical of data on a disease of an annual. Nevertheless, the pathographs of Figure 1 may be interpreted as indicating that treatment 2 is noticeably superior and is worthy of further and more detailed study. The nature of the data in Table 2 is such that they are not subject to the limitations placed on the interpretation of Table 1 and Figure 1. The sites of Table 2 vary from poorly drained, through old field successional stages, to a housing area. The pathographs of Figure 2 are interpreted by the writer as follows: There is no indication that site is an important factor in this disease. The disease is not spectacular. No alarming proportions of it are likely to be found at any one time in any one place. Its damage develops gradually over a period of years.

Pathographs may be of considerably more use than is evident from the examples in this report. For instance, the pathographs suggested might be of use to forest pathologists by serving as a basis for comparing the response to the same type of disease of two or more suscept species growing in the same area. Furthermore, these pathographs might be made a part of the permanent records of permanent plots established for the study of a disease of a perennial. Thus, new pathographs made each year would present in graphical form the changes in relative importance of the disease on each site.

Apparently phytographs as now used have become standardized so that all ecologists use the same formulas for deriving the numerical values for the four characteristics. This means that ecologists by habit interpret a given figure the same way each time it appears. This discussion, however, indicates that the details of a pathograph comparison will have to be adjusted more or less for each new situation. At present perhaps more will be sacrificed in attempting to standardize formulas for pathographs than the resultant uniform pattern of interpretation will merit. The varying natures of plant diseases might mean that these formulas can never be standardized. All this justifies repeating the warning that, pending standardization, extreme care must be exercised in delimiting all factors such as size classes, vigor classes, maturity classes, etc. which might be used in conducting surveys to obtain data for pathographs. Equal care should be exercised in utilizing these classes in formulas and calculations. In the event the pathographs are for publication it is doubly important to give the formulas and indicate clearly the numerical limits and other bases for all factors used in them.

Literature Cited

1. Garren, K. H. 1950. A possible adaptation of the phytograph for use in interpreting plant disease research. Abstr. Phytopathology 40: 787-788.
2. Garren, K. H. 1954. Second report on leader dieback of sweetgum. Plant Dis. Reptr. 38: 91-92.
3. Hutchinson, A. H. 1940. Polygonal graphing of ecological data. Ecology 21: 475-478.
4. Lutz, H. J. 1930. The vegetation of Hearts Content, a virgin forest in northwestern Pennsylvania. Ecology 11: 1-29.
5. Oosting, H. J. 1948. The study of plant communities. 389 pages. Illus. Freeman, San Francisco.

HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, VIRGINIA AGRICULTURAL EXPERIMENT STATION COOPERATING, (TIDEWATER RESEARCH STATION, HOLLAND, VIRGINIA)

POTENTIAL PLANT PATHOGENIC FUNGI IN SEWAGE AND POLLUTED WATER

Wm. Bridge Cooke[1]

The literature of sewage and waste disposal contains many references to the use of sewage as a source of supplemental irrigation water. References are increasing as studies are made in drier parts of the country where sewage and other wastes are of increasing interest in reclamation of water.

Skulte (1956) states: "Skillfully designed and properly managed sewage farming has been operated for decades in Europe, and for several years in some localities in the southwestern areas of the United States, without danger to personnel and without creating nuisance conditions. As a new science, irrigation with sewage effluent is still in the experimental stage and many problems need to be solved in the fields of bacteriology, biology, hygiene, soil structure and the physiology of plants,"

State and federal agencies have been interested for many years in the use of sewage as an irrigation supplement. Most communities in the United States could use supplemental irrigation (Hunt, 1954) during annual periods of drought. Methods of reclaiming sewage for reuse in irrigation have been described by Hutchins, 1939, and are being studied by the State of California (Bush and Mulford, 1954; Merz, 1955). "Water", the Yearbook of Agriculture for 1955, shows in several articles both by Department of Agriculture personnel and by Public Health Service personal an under-current of interest in this problem. On the research level, certain recent studies indicate some of the problems involved. The effect of spreading rather than furrowing in irrigation technique has been investigated by Bush and Mulford (1954) and by Greenberg and Thomas (1954). A study by Henry et al. (1954) was designed to indicate the influence of sewage waters on mineral content, organic content, soil structure, and other aspects of soil quality. In such studies it has been found that the most important mineral problem is that of boron which sewage seems to add to soils.

In a popular article by Stone (1955) it was pointed out that sewage could be used for irrigation in a number of places. In addition to irrigating crop plants, he thought, it could be used for the irrigation of lawns and ornamental plantings. Illustrations of both types of use are given in his article.

In his new book, "The Biology of Root-Infecting Fungi" Garret sums up his thesis with a statement to the effect that until a crop is grown in a soil free from disease organisms one cannot appreciate the resulting gains in crop values or the typical healthy nature of the plants that develop in such conditions. We may assume that this statement can also supply a contrast to soils into which disease organisms, however unapparent they may be, are dumped on a periodic and perhaps daily schedule.

Menzies (1954) has pointed out that certain plant pathogens have become more and more a problem to the plant pathologist as the practice of irrigation increases in the Columbia Basin. Those pathogens mentioned are airborne leaf and fruit diseases rather than waterborne soil fungi and either have been introduced with the crop or have migrated in much the same manner as other rusts, mildews, and host-restricted pathogens. His forecast that other diseases could become important in the region is of interest.

Two of the fungi isolated occasionally from sewage and polluted water are Fusarium oxysporum and F. solani. Strains of both have been recovered at one time or another from domestic sewage used as "seed" in experiments at the Robert A. Taft Sanitary Engineering Center. To determine the degrading ability of sewage organisms for various types of industrial wastes, small amounts of such sewage are seeded into dilution water containing known quantities of the wastes or materials to be studied. In one such experiment, hydrocarbons in the form of motor oil were subjected to domestic sewage. During the period of observation two groups of organisms developed in large quantities, a protozoan and a strain of F. oxysporum. In a later experiment this strain of F. oxysporum was added to a suspension of motor oil in dilution water. After three weeks (Ludzack and Kinkead, 1955) the fungus had produced almost as much breakdown of the oil as had the domestic sewage which was tested at the same time in similar solutions. Similar sewage seed had been used to develop a slime on an experimental trickling filter in which hydrocarbons of airplane cleaning materials were treated. Upon plating the slimes it was found that a strain of F. solani was the predominant fungus present.

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Prior to 1952, the presence of fungi in polluted water and sewage was considered by workers in the field of sanitary science to be an established fact but not worthy of special investigation. It was obvious that under certain conditions of pollution a stream or a trickling filter would develop growths thought to be fungi, some of which were identified as to species in occasional studies (Cooke, 1954a). No reference to the isolation or identification of plant pathogens as such from raw sewage or partially treated waters has been reviewed.

The routine study of a small polluted stream (Cooke, 1954c), of a large secondary-type sewage treatment plant at Dayton, Ohio (Cooke, 1954b) at monthly intervals, and of other habitats at less frequent intervals, yielded quantitative and qualitative data on the presence of soil fungi in these habitats. Various media were tested and techniques used which are common to soil microbiology (Cooke, 1954b). From such studies it appears that certain strains of species of soil fungi have become acclimated to living in aqueous habitats. Spore production is atypical when present, and certain tested species are able to use dissolved oxygen in competition with other sewage organisms for reduction of organic materials (unpublished data). Most of the species tested are able to produce their own vitamin supply, and all are able to utilize simple sugars and organic as well as ammonia nitrogen.

Garrett considers seedling blight and vascular wilt fungi as "ecologically obligate parasites"; that is, while they are able to grow alone or with other fungi on culture plates, in the soil they appear unable to compete with strictly saprobic fungi for the dead organic matter that occurs there. On the other hand, there is evidence that in sewage and related habitats they can reproduce, as indicated by the observations on degradation of hydrocarbons.

In addition to the two strains of Fusarium species mentioned, other fungi have been found that are capable of attacking plants in the field, or plant products in the field, in harvesting, in storage, in transit, and on the market. Species in the accompanying list (Table 1) have been isolated from polluted waters and sewages. Some of the species on this list may be of little importance, but all have been cited in one reference or another as causes of disease in plants, associated with seed in storage, or causes of various types of rots and decays in storage, transit, and market. Most of the species in this list are mentioned prominently in "Plant Diseases", the 1953 Yearbook of Agriculture.

Table 1. Fungi of interest to the plant pathologist isolated from polluted water and sewage.

Alternaria tenuis	Fusarium solani
Aspergillus flavus	Gliocladium catenulatum
Aspergillus fumigatus	Gliocladium roseum
Aspergillus niger	Mucor - several species
Aspergillus terreus	Penicillium brevi-compactum
Botrytis cinerea	Penicillium chrysogenum
Cephalosporium spp.	Penicillium cyclopium
Chaetomium funicolum	Penicillium digitatum
Chaetomium globosum	Penicillium expansum
Cladosporium cladosporioides	Penicillium italicum
Coniothyrium fuckelii	Penicillium martensii
(and other sphaeropsidaceous fungi)	Penicillium oxalicum
Curvularia lunata	Penicillium rugulosum
Fusarium aquaeductuum (episphaeria)	Rhizopus nigricans and other species
Fusarium moniliforme	Scopulariopsis brevicaulis
Fusarium oxysporum	Stemphyllium consortiale
Fusarium roseum	Trichoderma viride

The fungi chosen for presentation in Tables 2 and 3 are among the commoner species that have been isolated from sewage and polluted water and have been listed in the literature of plant pathology as causing damage to growing plants or their products in the field, storage, transit, or market. Alternaria tenuis is listed in the broadest sense as including any isolate that has the morphological characteristics assignable to the species. Thus, several species of perfect fungi may be included in this category. The three species of Aspergillus cited are commonly associated with various types of storage, transit, and market decays, and some are

Table 2. Occurrence of potentially plant pathogenic fungi isolated from Lytle Creek, Clinton Co., Ohio (Number of colonies in thousands per gram dry weight of four combined samples at each station in stream)

Station[a] and Fungus	1952									1953		
	Mar. 3	Apr. 17	May 15	June 12	July 10	Aug. 7	Sept. 18	Oct. 23	Nov. 26	Jan. 14	Feb. 25	Mar. 30
STATION 8.7												
Alternaria tenuis	8	0	0	0	0	0	0	0	0	0	0	0
Aspergillus fumigatus	172	20	124	30	10	24	8	40	20	30	20	20
Aspergillus niger	0	8	8	10	0	0	0	0	0	14	0	0
Fusarium oxysporum	0	0	0	18	0	0	0	0	0	0	0	0
Fusarium solani	0	0	10	0	0	0	0	0	0	54	0	0
Penicillium oxalicum	0	0	0	0	0	0	0	0	34	0	0	0
Sphaeropsidales	8	38	108	0	0	0	100	140	0	342	0	0
STATION 7.6												
Alternaria tenuis	0	0	0	0	0	0	0	24	0	40	62	80
Aspergillus fumigatus	16	186	24	58	26	0	10	0	20	50	34	54
Aspergillus niger	8	0	16	10	0	0	0	72	520	444	50	0
Fusarium oxysporum	18	0	0	0	0	0	0	0	0	0	0	0
Fusarium solani	0	0	0	0	0	0	0	0	0	24	0	0
Penicillium oxalicum	0	0	0	0	0	0	0	16	70	0	0	0
Sphaeropsidales	32	36	0	0	0	16	20	8	14	202	10	0
STATION 7.2 + 6.5												
Alternaria tenuis	0	0	8	0	10	0	0	100	34	44	0	28
Aspergillus fumigatus	218	44	178	30	0	32	10	3216	420	68	64	34
Aspergillus niger	0	0	0	8	0	0	100	0	0	10	0	0
Fusarium oxysporum	0	0	0	32	0	0	88	0	0	14	0	0
Fusarium solani	x	0	48	0	8	0	0	0	0	0	0	0
Penicillium oxalicum	0	0	108	0	0	0	0	42	1530	20	0	0
Sphaeropsidales	16	336	26	0	0	100	8	24	30	474	114	0
STATION 5.2 + 4.2												
Alternaria tenuis	0	0	0	0	0	0	0	0	10	30	70	74
Aspergillus fumigatus	226	182	124	118	52	100	26	40	20	100	82	74
Aspergillus niger	0	26	0	0	10	0	100	0	10	0	0	14
Fusarium oxysporum	0	0	0	0	0	20	56	0	0	0	0	0
Fusarium solani	0	0	0	0	0	0	0	0	0	0	0	0
Penicillium oxalicum	0	0	0	0	0	8	104	100	60	54	0	0
Sphaeropsidales	34	40	0	0	0	0	112	290	54	2868	164	10
STATION 2.8 + 1.0												
Alternaria tenuis	0	0	8	8	0	0	10	0	24	10	406	400
Aspergillus fumigatus	244	72	18	52	58	34	0	0	14	0	96	14
Aspergillus niger	500	8	0	0	200	8	108	0	14	0	48	0
Fusarium oxysporum	8	0	0	36	0	10	0	0	0	150	0	0
Fusarium solani	0	0	0	0	30	0	0	0	0	1974	0	0
Penicillium oxalicum	0	8	10	10	56	216	16	108	150	10	24	68
Sphaeropsidales	0	0	146	0	0	18	36	268	52	100	118	64

[a]Stations numbered according to distance in miles from mouth of creek. Stations fall in following pollution zones: clean water 1.0, 2.8, 8.7; zone of recovery 7.6, 4.2; Septic zone, 5.2, 6.5, 7.2; point of outfall from Wilmington, Ohio Sewage Treatment Plant, 7.2. See also Cooke (1954c) and Gaufin and Tarzwell (1952)

Table 3. Occurrence of potentially plant pathogenic fungi isolated from the sewage treatment plant, Dayton, Ohio. (Number of colonies in thousands per gram dry weight of sample.)

Station and Fungus	1952							1953				
	Apr. 3	June 16	July 17	Aug. 14	Sept. 25	Oct. 30	Dec. 10	Jan. 29	Feb. 12	Mar. 19	Apr. 14	Aug. 19
IMHOFF TANK SCUM												
Alternaria tenuis			0	0	0	0	0	0	0	100	0	100
Aspergillus flavus			150	0	225	172	0	100	100	100	200	100
Aspergillus fumigatus			450	0	0	0	0	0	0	0	0	0
Aspergillus niger			600	0	450	258	200	200	100	200	100	0
Fusarium solani			150	0	0	258	0	0	0	0	0	0
Penicillium oxalicum			0	0	0	86	0	0	0	0	0	0
Sphaeropsidales			0	0	375	0	0	0	200	100	0	0
IMHOFF TANK SLUDGE												
Alternaria tenuis		0	0	0	0	0	0	0	0	170	0	170
Aspergillus flavus		0	260	0	0	0	0	0	340	0	0	0
Aspergillus fumigatus		0	390	0	260	300	170	0	0	0	0	0
Aspergillus niger		0	520	200	200	150	170	0	0	0	0	0
Fusarium solani		650	0	1170	0	1800	0	0	0	0	0	0
Penicillium oxalicum		0	0	520	650	0	0	170	0	0	0	0
SECONDARY DIGESTER SLUDGE												
Aspergillus flavus		0	220	0	0	0	0	0	0	0	0	0
Aspergillus fumigatus		110	220	0	110	0	0	0	150	0	0	0
Aspergillus niger		110	350	110	0	130	0	0	0	0	0	0
Fusarium solani		0	330	0	0	0	0	0	0	0	0	0
Sphaeropsidales		0	0	1100	4070	0	0	0	0	0	0	0
SCRAPINGS, HIGH-RATE FILTER SURFACE												
Alternaria tenuis	0	0	0	0	0	0	0	0	830	830	0	0
Aspergillus flavus	0	0	0	0	0	1540	0	0	0	830	0	0
Aspergillus fumigatus	630	0	2520	0	2520	0	0	0	0	0	0	1660
Aspergillus niger	0	0	630	1260	1890	770	1660	830	0	0	0	830
Penicillium oxalicum	0	0	0	0	0	0	0	0	0	0	0	830
Sphaeropsidales	630	0	0	1260	0	0	0	0	0	1660	830	0
SCRAPINGS, STANDARD RATE FILTER SURFACE												
Alternaria tenuis	1260	0	0	0	0	0	1660	0	1660	830	0	2490
Aspergillus flavus	0	0	0	630	0	0	0	0	1660	0	0	0
Aspergillus fumigatus	1260	0	1890	0	0	0	0	0	0	0	0	0
Aspergillus niger	0	0	0	630	630	770	830	830	0	0	0	830
Sphaeropsidales	2500	0	0	4440	3150	1540	830	830	830	0	1660	1660
FRESHLY POURED SLUDGES												
Alternaria tenuis	0	0	0	0	0	0	0	0	144	0		72
Aspergillus flavus	0	0	54	0	0	124	0	0	0	0		0
Aspergillus fumigatus	0	0	108	162	0	62	216	0	0	72		0
Aspergillus niger	108	0	54	108	54	124	0	0	72	72		0
Fusarium solani	0	0	0	0	0	62	0	0	0	0		0
Penicillium oxalicum	54	0	0	0	0	0	0	0	0	0		0
Sphaeropsidales	0	0	0	1134	1180	62	0	0	72	72		0
MEDIUM-DRY SLUDGE												
Alternaria tenuis	0	0	0	0	30	0	0	0	0	0	0	0
Aspergillus flavus	0	0	0	0	0	0	0	0	120	0	0	0
Aspergillus fumigatus	0	0	0	0	0	34	40	80	40	0	0	0
Aspergillus niger	30	0	30	60	0	0	40	40	40	0	0	0
Penicillium oxalicum	0	0	0	0	0	0	0	0	0	40	0	0
Sphaeropsidales	0	0	0	60	0	34	0	0	0	0	0	0
AIR-DRIED SLUDGE												
Alternaria tenuis	0	0	0	0	0	0	0	110	0	0	0	0
Aspergillus flavus	0	0	81	2511	81	0	0	0	110	0	0	0
Aspergillus fumigatus	972	0	0	0	38800	0	0	0	0	0	0	0
Aspergillus niger	0	81	0	405	0	0	0	0	110	0	0	0
Fusarium solani	0	0	0	162	0	0	0	0	0	0	0	0
Sphaeropsidales	0	0	243	0	12960	0	0	0	0	0	0	0
HEAT-DRIED SLUDGE												
Aspergillus flavus								368	0	368		0
Aspergillus fumigatus								0	184	920		184

commonly isolated from seeds. Several strains of Fusarium oxysporum and F. solani may be present in the region, but which of these are involved in the sewage isolations is not known. In order to determine this properly the cultivated and wild flora of the area should be screened for susceptibility to attack by these fungi. Penicillium oxalicum is reported to cause a seedling disease of corn, and it is also isolated on occasion from ears and seeds. Its occurrence in the area is of interest, since corn is one of the important crop plants there. The category "Sphaeropsidales" includes between 5 and 20 species, depending on the amount of variation permitted to occur within one species of imperfect fungi. Such genera as Coniothyrium, Phoma, Spaeronema, and Ascochyta are present, and one of the commoner species has been identified as Coniothyrium fuckelii.

The habitats mentioned in Tables 2 and 3 are described more fully elsewhere (Cooke, 1954b and c) but may be briefly summarized here. Lytle Creek is a small stream in the Little Miami River basin and empties into Todd's Fork. It originates east of the City of Wilmington and flows through rolling farm land for about 10 miles. Before it received the effluent from the Wilmington sewage treatment plant, it was an intermittent stream. When the study was made on which Table 2 is based, Wilmington had a primary-type treatment plant in which solids were settled out and the liquids, sometimes treated chemically, were discharged into Lytle Creek. An activated sludge plant has since been installed, and zonation on the creek is probably much different because the stream is receiving much less polluted water. The sewage effluent is released into the creek at Station 7.2. At Station 8.7 (8.7 miles above the confluence with Todd's Ford), very little effect of pollution is noticed; the only sources of pollution are septic tank overflow and other runoff from farm lands and houses. Station 7.6 is somewhat polluted because of a break in the main leading from the city to the treatment plant. Below Station 7.2 the various sampling points were selected as indicative of the gradual return of the stream to clean conditions, and the various stations have been sampled for all types of stream life in order to describe this situation more completely.

The fact that a number of species of fungi are able to survive under conditions of extreme pollution and even dilution of this pollution indicates a major adjustment in their life requirements. It further indicates that they are probably aiding in the purification of the stream. If they are aiding in stream purification by using as food some of the various types of pollutant materials, this may indicate that they are both increasing the size of their thallus and producing spores. The production of spores in situations like this, which are subject to occasional tapping for irrigation water at least in some parts of the country, indicates that here is a potential source of inoculum for plant disease and pest species. In many cases this source need be present only for a limited period of time.

Nine of the 16 sampling points studied in the Dayton, Ohio, sewage treatment plant are listed in Table 3. These nine were chosen because they are locations where the largest build-up of fungus populations occurs or because they can be of importance as sources of fungus contamination through use as fertilizer or soil conditioner. While not listed, various effluents can be of some, although lesser, importance as indicated by Becker and Shaw (1955).

During the sampling period the flow chart at Dayton was similar to that of many secondary-type sewage treatment plants using trickling filters. Sewage entered the treatment plant through the detritus tanks in which large particulate matter is screened out. From here it flowed to Imhoff tanks for primary settling. The liquid flowed to the trickling filter dosing tanks, from which it was routed to either the high rate or standard rate filters. These filters are cement tanks 165 feet in diameter and 7.5 feet deep. They are filled with slag rock 1.5-3 inches in diameter, on which slime has developed including such organisms as bacteria, fungi, algae, and protozoans. The liquid sewage passes over this stone and out of the filters into a final settling basin and thence to the Great Miami River. Sludge in the final settling basin was returned to the Imhoff tanks to repeat the cycle. Sludge from the Imhoff tanks was passed to secondary digesters and then to drying beds where it was air-dried, removed, ground up, passed through a heated oven, pulverized, and sacked for sale as an organic soil conditioner.

In certain communities, sewages in various stages of treatment are used as sources of irrigation supplements. The raw sewage used can contain fungal spores introduced from such source as runoff from soils following precipitation or lawn and flower bed irrigation; washings from infected or moldy plant parts, mildewed materials, etc.; or contaminated plumbing where growths can occur between intermittent flow periods. In other communities, effluents from primary settling tanks or Imhoff tanks are used; and in some cases, secondary treatment processes may be by-passed. In still other communities, effluents from complete or secondary plants may be employed. Depending on the type of treatment, that is, whether recirculation is practiced or whether the plant is overloaded, the effluent may be rich or poor in fungus dissem-

inules. There may be seasonal activity within the treatment plant or in the various places from which its populations are derived, which would give a seasonal pattern to the microorganisms in the effluent. The sludges used for supplemental fertilizers or soil conditioners may have developed a population of organisms that could produce trouble in the field or at least add to the populations of microorganisms in the field awaiting favorable conditions for infecting crop plants.

The paradox of this situation is that under certain circumstances a fungus that could cause considerable damage in a field could be actively purifying the sewage in which it is living. The test in which it was found that a strain of Fusarium oxysporum could reduce motor oil in dilution water is a case in point. Should a treatment for such wastes be developed in which this or similar fungi were the microbial agents, and should the effluents containing spores or other disseminules be applied as irrigation supplements indiscriminantly, it is likely that an inoculum for disease of a crop plant could develop and considerable economic loss result.

It thus appears that in these days of increased supplemental irrigation by use of sewage or polluted water the plant pathologist is presented with additional problems of disease control. Unfortunately, to control one fungus chemically may inhibit the work of many beneficial organisms, so that control measures necessary for irrigation waters should be applied to effluents rather than to influents of the sewage treatment plant. It is possible that adequate control of plant pathogens may also result in adequate control of human pathogens, so that a wider use could be made of sewage effluents than is being made today.

Literature Cited

Becker, J. G., and C. G. Shaw, 1955. Fungi in domestic sewage-treatment plants. Applied Microbiology 3: 173-180.

Bush, A. F., and S. F. Mulford. 1954. Studies of "waste water reclamation and utilization". California State Water Pollution Control. Board 9: 1-82.

Cooke, W. B. 1954 (a, b, c). Fungi in polluted water and sewage. I. Literature Survey. II. Isolation technique. III. Fungi in a small polluted stream. Sewage and Industrial Wastes. 26: 539-549, 661-674, 790-794.

Cooke, W. B. and P. W. Kabler. 1955. Isolation of potentially pathogenic fungi from polluted water and sewage. Public Health Reports. 70: 689-694.

Gaufin, A., and C. Tarzwell. 1952. Aquatic invertebrates as indicators of stream pollution. Public Health Reports. 67: 57-64.

Greenberg, A. E., and J. F. Thomas, 1954. Sewage effluent reclamation for industrial and agricultural use. Sewage and Industrial Wastes. 70: 689-694.

Henry, C. D., R. E. Moldenhauer, L. E. Englebert, and E. Truog. 1954. Sewage effluent disposal through crop irrigation. Sewage and Industrial Wastes. 26: 123-133.

Hunt, H. J. 1954. Supplemental irrigation with treated sewage. Sewage and Industrial Wastes. 26: 250-260.

Hutchins, W. A. 1939. Sewage irrigation as practiced in the Western States. U. S. Dept. Agr. Tech. Bull. 675: 1-59.

Ludzack, F. J., and D. Kinkead. 1955. The persistence of the motor oil class of hydrocarbons in polluted water under aerobic conditions. Mimeographed report, Robert A. Taft Sanitary Engineering Center. April 4. pp. 1-17.

Menzies, J. D. 1954. Plant disease observations in the irrigated areas of central Washington during 1953. Plant Dis. Reptr. 38: 314-5.

Merz, R. C. 1955. A survey of direct utilization of waste waters. California State Water Pollution Control Board 12: 1-80.

Schwab, C. E. 1955. Pollution-- a growing problem of a growing nation. Water, the Yearbook of Agriculture. pp. 636-643.

Skulte, B. P. 1956. Irrigation with sewage effluents. Sewage and Industrial Wastes. 28: 36-43.

Stone, R. 1956. Irrigation with waste waters. Public Works 86 (11): 97-98, 134-135.

United States Dept. of Agriculture. 1953. Plant Disease, The Yearbook of Agriculture. xviii + 940 pp. Washington, The United States Government Printing Office.

United States Dept. of Agriculture. 1955. Water, The Yearbook of Agriculture. xiii + 751 pp. Washington, The United States Government Printing Office.

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HOW THE POTATO ROOT NEMATODE WAS DISCOVERED IN ISRAEL[1]

G. Minz[2]

The temperatures for the development of Heterodera rostochiensis Woll. were reported by Fenwick (4) to be up to 21°C. Callam et al. (3) successfully used for their hatching tests a temperature of 24°C.

It was therefore thought unlikely that H. rostochiensis could develop to dangerous proportions in Israel, because of the climatic conditions. It was, however, felt that when once introduced into a country H. rostochiensis might, like other immigrant parasites, establish itself, reproduce and build up new generations. This development, of course, depends on the environmental conditions prevailing in the new country. It also depends on the hosts present.

Potatoes and tomatoes are grown intensively in Israel, either as winter crops or as spring and summer-crops. The spring and summer crops are grown under irrigation. Eggplants and weeds of the family Solanaceae may also serve as hosts, at least for the perpetuation of the parasite.

Climatic conditions during the winter and spring (especially with additional irrigation) may suit the development of H. rostochiensis very well.

The last link is the introduction of the parasitic organism. This could happen with both seed and table potatoes, imported from European countries, known to be infested with the potato-root nematode. Table potatoes are often accompanied by relatively large amounts of adhering soil (1 to 2 percent). Sometimes they are also used as seed tubers.

No regular inspections of fields for H. rostochiensis were carried out until 1955. The failure of both potato and tomato crops due to nematodes was always traced to root-knot nematodes (Meloidogyne sp.)

In general, except by smallholders, a sound crop rotation is maintained in this country. That is why H. rostochiensis could not develop to such extent as to cause visible injury and loss to the crop. Our suspicion that this nematode might be present in Israel grew with the discovery of that pest in Algeria (1).

The golden nematode was discovered by chance (5). It was probably imported with seed potatoes. Briefly, this is the story.

A smallholder succeeded in growing potatoes, mostly from imported seed, on his land (about 1 1/2 acres) for more than 10 successive years. He learned how to escape root-knot, how to spray and dust against diseases and pests; his yields were always high. Three years ago he started a citrus nursery on 3/4 of an acre, thinking this would be more profitable than growing potatoes. To his disappointment the seedlings developed slowly and were chlorotic; the root system was poor, having the appearance of stubby roots.

The soil was examined, but no parasitic nemas, which could cause the stubby condition, were found. Instead, cysts of Heterodera rostochiensis, some with eggs and larvae, were encountered (5). About 20 cysts per 200 g of dry soil were found. This is, according to the European code (2), less than a moderate infestation.

In connection with this discovery, inspections extending about 1 1/2 km. in diameter were carried out on fields in the neighbourhood of this infested spot where potatoes were previously grown. In one field, next to the nursery, a slight infestation was found (1 cyst per 200 g of soil). This field measures approximately 2 acres.

The stubby-root condition of the citrus seedlings was probably caused by the toxic concentrations of copper in the soil, an accumulated residue from the frequent and long use of copper spray and dust on the previous potato crops. Similar symptoms were described by Westgate on on celery, corn, and beans.

The assistance of Mrs. Ruth Berger and Miss Dina Harari is greatly appreciated. The author wishes to thank Mr. J. Mazali, potato grower and nurseryman, for this generous help in this investigation.

Literature Cited

1. Anon. 1954. Outbreaks and new records. Algeria. FAO Plant Prot. Bull. 2: 60.

2. Anon. 1955. Heterodera rostochiensis Woll. Report

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[1] Publication of the Agricultural Research Station, Rehovot, Israel, 1956 Series, No. 158 E.

[2] Division of Plant Pathology Agricultural Research Station, Rehovot, Israel.

of the Intern. Conf. Pot. Root Eelworm. European and Mediter. Plant Prot. Organisation.

3. Calam, C. T., H. Raistrick, and A. R. Todd. 1949. The potato eelworm factor. I. The preparation of concentrates of the hatching factor and a method of bioassay. Biochem. Jour. 45: 513-519.
4. Fenwick, D. W. 1951. The effect of temperature on the development of the potato root eelworm Heterodera rostochiensis. Ann. Appl. Biol. 38: 615-617.
5. Minz, G. and Ruth Berger. First record of Heterodera rostochiensis Woll. in Israel (In press).
6. Westgate, P. J. 1952. Preliminary report on copper toxicity and iron chlorosis in old vegetable fields. Proc. Florida State Hort. Soc. pp. 143-146.

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PRATYLENCHUS PENETRANS TESTED ON STRAWBERRIES GROWN IN BLACK-ROOT-ROT SOIL

D. J. Raski

Root rots are among the important diseases contributing to the general deterioration of strawberry plantings. These root diseases are widely distributed throughout the strawberry growing regions of the United States, Canada, Australia, Britain, and Europe, and are responsible for severe losses from premature decline or failures in commercial plantings.

One of the types of root rot has been referred to as the "black lesion type" or black root rot of strawberry. The conditions or agents responsible for black root rot have not been definitely established but the causes or contributing factors that have been suggested include winter injury (3), desiccation during transplanting (9), fungi, bacteria and nematodes.

Fungi have generally been considered to be the principal cause of black root (1, 3, 5, 11). Hildebrand and West (6) reported observations that indicated that certain bacteria may be an equally important component of the complex. Reports by Hildebrand and West (6) and Berkeley and Lander-Thomson (4) suggested that nematodes may be a factor in the cause of black root rot but nematodes were not included under controlled conditions in their experiments.

Field tests for the control of black root rot of strawberries by soil fumigations, according to Allen and Raski (2), resulted in improved growth which was also correlated with the control of a root-lesion nematode (later identified as Pratylenchus penetrans (Cobb). Klinkenberg (7) reported that root-lesion nematodes (Pratylenchus) isolated from infested soil produced root rot symptoms. Klinkenberg also presented further evidence (8) to support the belief that P. penetrans was the primary cause of black root rot. Recently (10) Pratylenchus coffeae (Zimm.) has been studied in its relation to decline of strawberry plants in Arkansas.

The work reported here includes soil fumigation and inoculation tests with P. penetrans to to demonstrate further, if possible, the influence of the root-lesion nematodes on the growth of strawberries planted in soil from the field previously reported by Allen and Raski (2).

PROCEDURE

In February 1952, soil was collected from the black-root rot infested strawberry field near Watsonville, California. Soil was also obtained from an adjacent apple orchard that was free from root-lesion nematodes. In addition, a loam soil used in normal greenhouse operations was mixed half-and-half with sand and used for another test series. This soil and sand is routinely treated with chloropicrin.

Nematodes for inoculations were obtained from the roots of sweetpeas grown in a portion of the strawberry field soil. After a suitable period of growth the roots were washed clean, cut into small pieces with scissors, and placed on muslin filters in funnels. Water was added to a level that kept the roots soaked at all times and was changed every 2 days to keep it clear of contaminants. The nematodes were drawn off at the bottom by a pinchcock and stored in clear tap water in beakers. The beakers were flooded with fresh tap water three times, with a minimum interval of 20 to 30 minutes between each flooding to allow the nematodes to settle by gravity, then the excess water was decanted. As soon as sufficient numbers were collected for one treatment, the nematodes in 500 cc of water were sprinkled on the test soil which was spread out in a thin layer on the headhouse floor. Then the soil was mixed thoroughly and potted to provide five replicates per treatment.

The soil treatments involving fumigants were accomplished in 1-gallon jars sealed for 48 hours. Ethylene dibromide was used at the rate of 0.25 cc of Dowfume W-40 (20% actual EDB by volume) per gallon jar. D-D was used at the rate of 0.25 cc and chloropicrin at 0.50 cc per gallon. After treatment the soil was potted and allowed to air for several days before nematodes were introduced.

Strawberry plants of the Shasta variety approximately 6 weeks old were planted to each pot on July 21 and grown in the greenhouse. The roots of each plant first were washed clean and trimmed to a uniform size. These were allowed to grow until November 4 (106 days), when fresh weights of top growth and roots were taken (Table 1). In addition, 5-gram samples from a composite of all roots from each treatment were obtained and nematodes extracted from them by the funnel technique already described. These figures are also recorded in Table 1.

Table 1. Average fresh weights and root-lesion nematode (Pratylenchus penetrans) counts from roots of strawberries grown for 106 days.

Treatment	Average fresh weight in gms. Roots	Total	Number nematodes per gram of roots
Strawberry Field Soil			
(a) Untreated check	7.12	25.24	249
(b) EDB fumigation	10.02	47.88	6
(c) EDB fumigation plus 250 nematodes	13.04	48.92	9
(d) D-D fumigation	12.82	66.66	0
(e) D-D fumigation plus 250 nematodes	9.60	51.32	22
(f) Chloropicrin fumigation	20.26	97.10	0
(g) Chloropicrin fumigation plus 250 nematodes	19.52	95.64	18
L.S.D. at the 5% level	6.43	24.27	
L.S.D. at the 1% level	8.71	32.89	
Apple Orchard Soil			
(h) Untreated check	9.40	38.06	0
(i) Untreated check plus 250 nematodes	10.68	38.20	14
(j) Chloropicrin fumigation	18.48	81.54	0
L.S.B. at the 5% level	5.26	28.05	
L.S.D. at the 1% level	7.65	40.80	
Greenhouse Loam and Sand			
(k) No nematodes added	16.86	69.60	0
(l) 250 nematodes added	14.58	70.80	47
(m) 1000 nematodes added	15.02	61.22	187
(n) 5000 nematodes added	16.86	66.50	363
L.S.D. at the 5% level	5.24	16.02	
L.S.D. at the 1% level	7.34	22.45	

DISCUSSION

Fumigation of the strawberry field soil with EDB very markedly reduced populations but did not eradicate the nematodes. Some improvement in the growth of the plants resulted, but not enough to be significant at the 5% level.

Fumigation with D-D eliminated Pratylenchus penetrans from the soil and a significant increase in growth was obtained. Treatment with chloropicrin produced an even greater response of plant growth. The addition of 250 root-lesion nematodes did not appear to influence the results obtained from fumigation.

FIGURE 1. Strawberry roots grown in untreated strawberry field soil.

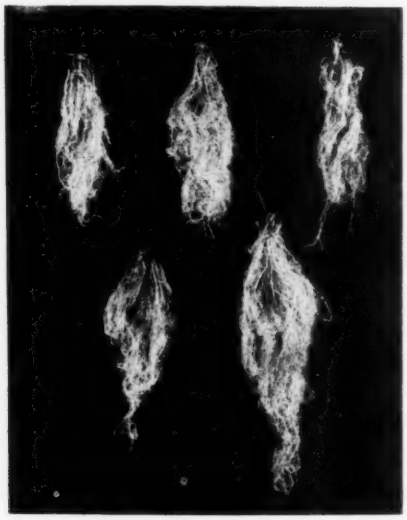

FIGURE 2. Strawberry roots grown in untreated adjacent apple orchard soil free of root-lesion nematodes.

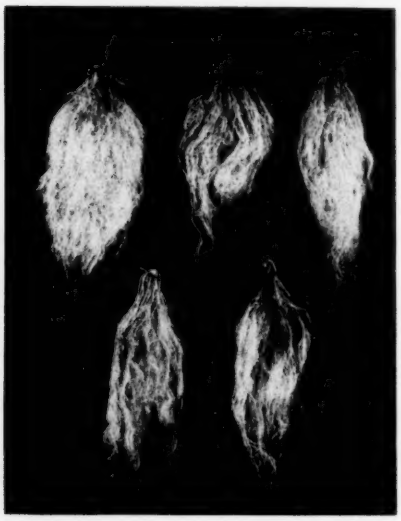

FIGURE 3. Strawberry roots grown in strawberry field soil fumigated with D-D.

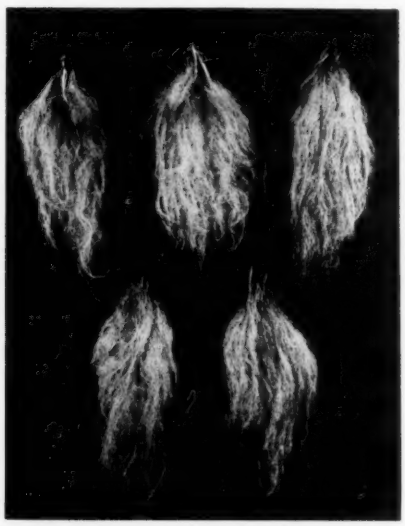

FIGURE 4. Strawberry roots grown in strawberry field soil fumigated with chloropicrin.

The relatively poor growth made by plants in untreated soil from the apple orchard is in contrast to the good condition of plants grown in soil from the same source fumigated with chloropicrin. This response to treatment occurred even though root-lesion nematodes were not present in this field soil.

The variation in fresh weights of strawberry plants grown in sterile soil inoculated with varying numbers of nematodes up to 5000 per plant was not significant at any level of inoculation. It should be pointed out that soil under field conditions may support much greater densities of nematode population than were tested here. With the aid of improved sampling techniques such levels can be determined more accurately and should be included in future tests. Also, the ultimate influence of P. penetrans on the growth of strawberries should be tested over longer periods of time, in consideration of the longevity normally expected of commercial plantings.

Unfortunately, comparative ratings of root rot symptoms were not obtained. It was clear that plants in untreated field soil were severely damaged, with blackened roots (Fig. 1), whereas those in chloropicrin-treated field soil were uniformly healthy and white (Fig. 4). Plants grown in apple orchard soil (Fig. 2) and D-D treated field soil (Fig. 3) were intermediate between the others.

These observations are not presented as conclusive but they do suggest that P. penetrans is probably not the most important factor limiting growth in this Watsonville, California, planting affected with black root rot.

Literature Cited.

1. Akenhead, D., et al. 1934. The "degeneration" of the strawberry. III. Root rot, by G. H. Berkeley. Imp. Bur. Fruit Prod. (East Malling) Tech. Commun. 5: 1-28.
2. Allen, M. W., and D. J. Raski. 1952. Nematodes on strawberries. California Agric. 6: 3, 14.
3. Berkeley, G. H. 1927. Strawberry diseases. Canada Dept. Agr. Bul. 80: 50-53.
4. Berkeley, G. H., and Isabel Lander-Thomson. 1934. Root rots of strawberry in Britain. The "black lesion" type of strawberry root rot. Jour. Pom. & Hort. Sci. 12: 222-246.
5. Hildebrand, A. A. 1934. Recent observations on strawberry root rot in the Niagara Peninsula. Canadian Jour. Res. 11: 18-31.
6. Hildebrand, A. A., and P. M. West. 1941. Strawberry root rot in relation to microbiological changes induced in root rot soil by the incorporation of certain cover crops. Canadian Jour. Res., C, 19: 183-198.
7. Klinkenberg, Caroline H. 1953. Zwart wortelrot van aardbeien. Tijdschrift over Plantenziekten. 59: 261-262.
8. Klinkenberg, Caroline H. 1953. Nematode diseases of strawberries in the Netherlands. Plant Dis. Reptr. 39: 603-606.
9. Miller, P. W. 1948. Studies on the cause of strawberry root rot in Oregon: second report of progress. Plant Dis. Reptr. 32: 309-316.
10. Riggs, R. D., D. A. Slack, and J. P. Fulton. 1956. Meadow nematode and its relation to decline of strawberry plants in Arkansas. Phytopathology 46: 24.
11. Strong, Forrest C., and Miriam C. Strong. 1931. Investigations on the black root of strawberries. Phytopathology 21: 1041-1060.

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DAMAGE TO TREE FRUITS IN NEW YORK BY ROOT LESION NEMATODES

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For several years cherry growers in certain areas in western New York have experienced failure of replants in old orchards and of new plantings in old orchard sites. These orchards are on light-textured usually well-drained soils, considered as our best orchard soils. The best known cultural treatments have been followed, and soil analyses show an adequate level of the major mineral nutrients and a satisfactory pH level. The organic matter content is the one factor found to be low. No evidence of injury by low winter temperatures is evident except a die-back at the tips of the branches, considered to be the result of weakness caused by some other factor.

That the root lesion nematode Pratylenchus penetrans (Cobb) is a major factor in this trouble was indicated by the field soil fumigation tests reported previously by Mai and Parker (1956). The present paper contains further evidence, based on inoculation experiments, that this nematode causes damage to cherry roots, and presents certain data on the prevalence of this nematode on cherry and on other tree fruit species.

Literature Review

No attempt is made to present a complete literature review on this subject pending more complete information, but it was thought worthwhile to cite certain papers to trace the major aspects of the development of knowledge of this genus of nematodes on tree fruits. Root lesion nematodes were shown to be pathogens of possible economic importance to deciduous tree fruits when Ark and Thomas (1936) described the occurrence of Anguillulina pratensis (de Man) synonym Pratylenchus pratensis (de Man) in the roots of poorly-growing apple, peach, pear, and plum trees in the Sebastopol area of California. By the addition of large numbers of these nematodes to small apple trees potted in sterile soil in the greenhouse root growth of the trees was sharply reduced. Allen and Jensen (1951) studied root lesion nematodes from the Sebastopol area and placed them in a new species, Pratylenchus vulnus Allen & Jensen.

Hastings and Bosher (1938), working in British Columbia, isolated meadow nematodes (P. pratensis) from root lesions on apple and cherry trees. They obtained infection in a number of cover crop plants grown in infested soil from the affected orchards. At that time all root lesion nematodes were considered as P. pratensis.

Young et al. (1950) obtained large numbers of lesion nematodes (Pratylenchus sp.) from root lesions on poorly-growing Mazzard cherry seedlings in Oregon nurseries. Certain cover crop plants, grasses, and weeds, including lamb's-quarters, in the same fields, were found to be attacked. Soil fumigation tests with nematocides gave better growth of both the cherry seedlings and the weeds in treated than in untreated plots.

Jensen (1953), working with P. penetrans obtained from a narcissus planting in Oregon, in host range studies in the greenhouse found all 33 plant species tested susceptible to attack by this nematode. Orchard grass, a common cover crop in New York orchards, was included in Jensen's tests. In a popular review article, Allen and Raski (1953) state that the root lesion nematode attacks a wide variety of tree fruits, including walnut, cherry, plum, fig, apple, peach, and apricot. Colbran (1953) concluded that infection by P. coffeae (Zimmerman) is the chief cause of poor growth of apple replants in old orchard sites in Australia.

In the paper cited earlier Mai and Parker (1956) reported that the growth of cherry trees planted in soil infested with P. penetrans previously treated with a nematocide was from two to four times that of untreated checks. Xiphinema sp. was present in this soil, sometimes in large numbers in certain fields in the area, and examination showed that these nematodes also were destroyed by the treatment, but comparatively small numbers were present in the soil of the test plots even in the untreated checks.

[1]Authors' acknowledgements. The county agricultural agents in the five counties involved called attention to many of the orchards in which studies were made. Particular thanks are due to Fred P. Corey, who gave unstintingly of his time in the work reported and whose advice was invaluable. Several workers helped with the identification and inoculation studies, including especially Mrs. Joyce Lewis and Mrs. Joanna Palermo.

Inoculation Experiments

In late summer, young Mazzard cherry seedlings that had been grown from seed in steam-sterilized soil were inoculated with large numbers of Pratylenchus penetrans (approximately 6000 individuals in each 3-inch pot) obtained from the roots of orchard grass collected in affected cherry orchards. Several weeks later, after these trees had stopped growing, several of the inoculated trees wilted, and growth was uniformly less on the inoculated trees than on the checks and leaf color was lighter green (Fig. 1). Many of the roots on the inoculated trees were dead, and all roots on affected trees were grayish in contrast to the normal white roots on the checks.

The roots were examined for nematodes and large numbers were found in the roots of inoculated trees (average of 1835 per root system of trees) with very few on the checks (average of 3 per root system of trees).

Field Experience

The typical distribution of diseased sour cherry trees within an affected area (Fig. 2) is partly at random and does not follow the pattern of poor growth usually associated with unfavorable physical soil conditions or poor nutrition. Large numbers of P. penetrans are commonly found on weakened trees in these areas but not on the very weakest ones, those making almost no growth. In a typical root system from an affected orchard tree (Fig. 3), one root has made fair growth in sharp contrast to the very poor growth in all the other roots on the tree, with an abundance of a bunchy type of growth resulting from rootlet proliferation. Most of the rootlets in these crowded bunches are dead. In Figure 4 is illustrated the rootlet condition on a normal tree, on one that has made poor growth, and on one that has made almost no growth at all. The roots of orchard grass (Dactylis sp.), crab-grass (Digitaria sp.), lamb's-quarters (Chenopodium sp.), and pigweed (Amaranthus sp.) growing in an affected cherry orchard were found to be infected by Pratylenchus penetrans.

Survey

In 1955, a limited survey was made, partly at random, within the major fruit-growing area along Lake Ontario and in Orange County in the Hudson River Valley. The cherry orchards examined were selected on the basis that an unexplained problem existed. The same was true of the other species examined except that certain plantings were examined because they stood in the neighborhood of cherry orchards that contained a demonstrated or suspected nematode problem (Table 1).

Substantial numbers of Pratylenchus penetrans were found in five of the sour cherry orchards examined in three counties. The numbers of nematodes found in the various root samples often were not correlated with the apparent damage to the roots. In fact, the lowest counts frequently were obtained from the most severely damaged roots, particularly those with few feeder rootlets. This indicates that populations of plant pathogenic nematodes are drastically reduced when their feeding depletes the food source. Oddly, one of the two sweet cherry orchards examined stood near a sour cherry orchard with a severe nematode problem but itself was making good growth and the roots contained few nematodes. One young apple orchard, examined because of unexplained poor growth, was shown to be heavily infested by the root lesion nematodes. The nematodes were found in the one pear and one plum orchard examined, although in these there was no apparent relation to poor growth. The occurrence of these nematodes was irregular in the peach orchards studied.

It is considered that these data lend support to the conclusion that cherry orchards are severely damaged by the root lesion nematodes and that apple trees very likely are damaged but probably to a lesser extent. Root lesions have been observed on peach, but data are insufficient to determine whether peach trees are significantly damaged. Data on the other fruits are too limited to warrant any conclusions except that the nematodes are common provided conditions are favorable for their growth. It is interesting that in several instances severe damage to cherry occurred in plantings that followed peach or apple. Sometimes there was a differential, greater damage where peach or apple had been grown previously than where another fruit species or other cultivated crops had preceded cherry in the same field.

Also of interest is the fact that all these orchards were growing on light-textured soils, usually well-drained, but sometimes on light soils with poor underdrainage. In one cherry orchard the problem is greater in one part of the field than in another, and the soil is lighter in the part

Table 1. Occurrence of Pratylenchus penetrans in New York State Orchards. Samples Collected in 1955.

Fruit Tree: Kind and Variety	Rootstock	Name of Grower	County	Soil Texture	No. of Trees	No. of Nematodes per Root Sample (Range)
Sour Cherry						
Montmorency	Mahaleb	Charles Bush	Monroe	Very light	1	Less than 20
Montmorency	Mahaleb	Neil Elliot	Monroe	Very light	3	Less than 20 to 109
Montmorency	Mahaleb	L. B. Goodridge & Son	Monroe	Light	31	Less then 20 to 263
Montmorency	Mahaleb	Charles Tabor	Niagara	Light	4	0 to more than 50
Montmorency	Mazzard	Horn Farm	Wayne	Heavy	2	0 to 24
Montmorency	*	William Wilson	Wayne	Light	1	59
English Morello	*	M. E. Norris	Wayne	Light	1	199
Sweet Cherry						
*	*	Charles Bush	Monroe	Very light	3	Less than 20 to more than 50
Napoleon	Mazzard	Neil Elliot	Monroe	Very light	2	Less than 20 to 48
*	*	Franklin Yarker	Monroe	Light	2	21 to 768
Apple						
Wealthy	Apple seedling	John Goodrich	Niagara	Light	3	Less than 20
Baldwin	Apple seedling	Horn Farm	Wayne	Heavy	2	0 to less than 20
McIntosh	Apple seedling	Neil Elliot	Monroe	Very light	2	0 to more than 50
Red Delicious (Clark Dwarf)	Apple seedling	Charles Bush	Monroe	Very light	1	1057
Peach						
Hale Haven	Peach seedling	Charles Tabor	Niagara	Light	2	0 to 40
*	Peach seedling	Charles Bush	Monroe	Very light	2	Less than 20
*	Peach seedling	L. B. Goodridge & Son	Monroe	Light	2	Less than 20
Seedling	*	Ludington	Monroe	Very light	1	Less than 20
Red Haven	*	Mills	Orange	*	1	Less than 20
Plum						
Stanley	Myrobalan	Hugh Sanderson	Orleans	Light	2	52 to 87
Stanley	*	James Affuso	Orange	*	1	Less than 20
Pear						
Bartlett	Pear seedling	John Goodrich	Niagara	Light	1	Less than 20

*Unknown

FIGURE 1.
Root damage and poor growth of young Mazzard cherry seedlings caused by Pratylenchus penetrans. Tree on right inoculated with nematodes. Uninoculated tree on left.

FIGURE 2.
Montmorency cherry on Mahaleb rootstock showing typical distribution of very poor to moderate growth associated with nematode damage to the roots.

FIGURE 3. Root system of young (3- to 4-year-old) sour cherry tree on Mahaleb rootstock from an orchard with a severe nematode problem. Only one small root made appreciable growth. Most of larger roots were present at time tree was planted.

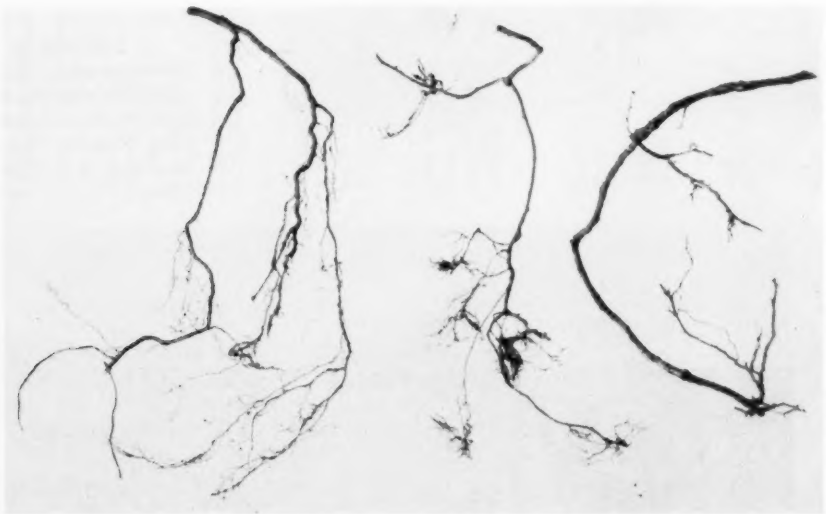

FIGURE 4. Roots from 3 sour cherry trees on Mahaleb rootstock from an orchard with a moderately-severe nematode problem. Root on left from a normal tree; one in middle from tree with moderate damage; one on right from tree making almost no growth. Note crowded rootlets on root in middle and virtual absence of feeder rootlets on root from poorest tree.

where the damage has been greater. This field had all been in apple trees previous to the time the cherries were planted.

Apparently, both Mazzard and Mahaleb cherry rootstocks are damaged by these nematodes although in general the trees on Mazzard roots seem to be growing somewhat better. No direct comparison has so far been possible, and experimental plantings on the two rootstocks are not yet old enough to provide a valid comparison of performance.

Substantial numbers of Xiphinema sp. have been found in soil adjacent to roots of poorly growing sour cherry, sweet cherry, peach, and apple trees. Large populations of Criconemoides sp. were found in soil samples from problem peach, sour cherry, and plum orchards, while large numbers of Paratylenchus sp. were found around a poorly-producing peach tree in a single orchard. No data are available concerning the relationship between the presence of these potentially pathogenic nematodes and the poor growth of the trees.

Summary

Inoculation tests in the greenhouse showed Pratylenchus penetrans to be pathogenic to Mazzard cherry roots. The nematodes used were obtained in an area where severe damage is done to young cherry trees planted in the orchards, but the nematodes used in the tests were isolated from orchard grass.

A limited survey indicates that this problem is greatest in one area where the soil is very light-textured. It is present but less damaging in sour cherry orchards on medium-textured soils and apparently nonexistent on heavy soils. These last soils, however, are so heavy that factors other than nematodes limit cherry tree growth.

Evidence of substantial damage to apple trees and moderate damage to peach roots was obtained. Evidence indicated that this species of nematode is present in potentially damaging numbers in orchards where the soil is light-textured and a favorable host has been grown previously.

Literature Cited

1. Allen, M. W., and H. J. Jensen. 1951. Pratylenchus vulnus, new species (Nematoda: Pratylenchidae), a parasite of trees and vines in California. Proc. of Helm. Soc. of Washington. 18: 47-50.
2. Allen, M. W., and J. J. Raski. 1953. The nematode menace in western soils. American Fruit Grower (Western Ed.). 73(2):32A-32B.
3. Ark, P. A., and H. Earl Thomas. 1936. Anguillulina pratensis in relation to root injury of apple and other fruit trees. Phytopath. 26: 1128-1134.
4. Colbran, R. C. 1953. Problems in tree replacements I. The root lesion nematode, Pratylenchus coffeae Zimmerman as a factor in the growth of replant trees in apple orchards. Australian Jour. of Res. 4: 384-398.
5. Hastings, R. J., and J. E. Bosher. 1938. A study of the pathogenicity of the meadow nematode and associated fungus, Cylindrocarpon radicicola Wr. Canadian Jour. of Res. 16 (C): 225-229.
6. Jensen, H. J. 1953. Experimental greenhouse host range studies of two root-lesion nematodes, Pratylenchus vulnus and P. penetrans. Plant Dis. Reptr. 37: 384-385.
7. Mai, W. F., and K. G. Parker 1956. Evidence that the nematode, Pratylenchus penetrans, causes losses in New York State cherry orchards. Phytopath. 46: 19 (Abst.).
8. Young, Roy A., D. C. Torgeson, and C. G. Anderson. 1950. Meadow nematodes on Mazzard cherry and forage plants and weeds in nursery rotations. Pl. Dis. Rep. 34: 230-231.

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HETERODERA FICI KIRJANOVA 1954 IN CALIFORNIA

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Soil and root samples from a specimen of Ficus elastica showing poor growth in a nursery at San Bernardino, California, were collected November 29, 1954. Numerous females of Heterodera were found on the roots, as well as numerous larvae, males and cysts in the surrounding soil.

Since then Ficus elastica plants have been sampled in seven nurseries in Southern California and six of these nurseries have been found to harbor Heterodera fici Kirjanova 1954 (1). In the field Heterodera fici was found on the Mission variety of the commercial fig, Ficus carica, July 24, 1955 in Yolo County, California.

Infection of plants by greenhouse inoculations has been successful only in the genus Ficus. Plants which did not become infected when grown in soil containing Heterodera fici include sugar beet (Beta vulgaris), cauliflower (Brassica oleracea), orchard nettle (Urtica urens), common nettle (U. gracilis), and hop (Humulus lupulus). The following Ficus species and varieties have become infected under similar greenhouse conditions: Ficus elastica, F. elastica var. variegata, and F. carica varieties Brown Turkey, Mission, Calimyrna, and Kadota.

The pathogenicity of H. fici to the commercial varieties of Ficus carica and other members of the genus Ficus has not been determined.

The identification of Heterodera fici was based on Kirjanova's original description and drawings. Cooper (2) considered H. fici a synonym of H. humuli Filipjev 1941. As we could not get this species to infect nettles or hops, the species in California on Ficus spp. in considered to be Heterodera fici Kirjanova 1954.

These collections represent the first record of this nematode in the United States.

Literature cited:

1. Kirjanova, E. S. 1954. Plant Nematology in the U.S.S.R., retrospect and prospect. Transactions of Problematic and Thematic Conferences. Moscow Acad. Sci. U.S.S.R. (In Russian) 3: 9-47.
2. Cooper, Beowulf A. 1955. A preliminary key to British species of Heterodera for use in soil examination. Proc. Univ. Nottingham Second Easter School Agr. Sci. Soil Zoology. pp. 269-280.

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IDENTIFICATION OF TRISTEZA IN MEYER LEMON IN ARIZONA

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In July 1955 the Arizona Commission of Agriculture and Horticulture requested a preliminary survey for the presence of tristeza in citrus in that State. The survey, begun in October 1955, was based on an examination of Meyer lemon trees because of the high incidence of tristeza in this variety as reported in Texas by Olson (1) and in California by Wallace and Drake (3). The few avaliable old satsuma mandarin trees were included also, for Olson (1) has reported the occurrence of tristeza in some early introductions of satsumas.

The indexing work was done at Indio, California, in a well-screened greenhouse in which insect control is maintained. All live plants or plant parts are killed before removal from this greenhouse. The budwood collections were indexed on Mexican lime seedlings, by the methods of Wallace and Drake (2). Usually two buds per seedling, each bud from a different bud stick, were used. The index plants were observed for almost 6 months, at the end of which time the bark was peeled from all the lime seedlings for observations on stem pitting. The first symptoms of tristeza, vein-clearing in leaves, were visible about 1 month after budding and by the end of 3 months vein-clearing and yellowing were present on the lime seedlings inoculated from nearly all collections except the satsumas. A few lime seedlings grew poorly and were slow in developing leaf symptoms. In some of the seedlings, no stem pitting had developed by the time of examination; these are being held for further observation.

Typical leaf symptoms of tristeza in Mexican lime were obtained from all 41 collections of Meyer lemon from commercial citrus groves, nurseries, and ornamental plantings in Arizona. Stem pitting developed on the index plants for 37 of the collections. The collections indexed, which represent only a sample of this widely scattered variety, were distributed as follows: Salt River Valley, 28; Yuma Mesa, 6; and Tucson, 7. Where these Meyer lemons were found in old commercial groves, there was no apparent evidence of tristeza in the adjacent trees of other varieties, even though the greater part of the older plantings are on sour orange rootstock.

In 8 instances, budwood was available both from Meyer lemon and from either the rootstock on which it had been grafted or from a second variety of citrus on which Meyer lemon also had been propagated as one or more small branches. Tristeza was identified in both components of 6 of these combinations. The negative cases were (a) the trifoliate-orange rootstock of one positive Meyer lemon and (b) the Washington Navel orange portion of a tree of that variety top-worked with a positive Meyer lemon. The negative collections are being held for further study.

One tree, originally a tangerine on Rough lemon, had been partially top-worked with Valencia, an unknown sweet orange, and a Meyer lemon. Tristeza was recovered from all 5 components.

Four satsuma trees, representing at most 3 old budwood sources, were indexed and yielded negative results.

Literature Cited

1. Olson, E. O. 1955. A survey for tristeza virus in Texas citrus. Proc. 9th Annual Rio Grande Valley Hort. Inst., pp. 51-60.
2. Wallace, J. M., and R. J. Drake. 1951. Newly discovered symptoms of quick decline and related diseases. California Citrograph 36: 136, 168-169.
3. Wallace, J. M., and R. J. Drake. 1955. Tristeza virus Meyer lemon. California Citrograph 40: 84, 95-96.

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THE INHERITANCE OF RESISTANCE TO STRAINS OF BEAN YELLOW MOSAIC VIRUS IN THE INTERSPECIFIC CROSS PHASEOLUS VULGARIS X P. COCCINEUS[1]

James R. Baggett

SUMMARY

In a study of the inheritance of resistance to bean yellow mosaic virus in the interspecific cross P. vulgaris (lines of the Blue Lake variety) X P. coccineus, the runner bean, 658 F_2 plants and a small number of F_1 individuals were tested by means of rub-inoculation in the greenhouse. Two severe pod-distorting strains of BYMV were employed for testing.

Infections of the F_2 plants ranged from severe to a symptomless condition in which the the virus could be detected only by subinoculations on plants of a susceptible variety. Ratios of infected versus uninfected plants were variable for the three groups inoculated, and suggested that two or three major recessive gene pairs conditioned the inheritance of the resistance or immunity of the P. coccineus parent. The wide and continuous variation in symptom expression indicates the effects of modifying genes.

The possible value of this cross in breeding programs and the problems of symptomless carriers are discussed.

INTRODUCTION

Since 1953, studies have been made at Oregon State College to determine the inheritance of resistance to bean yellow mosaic virus in crosses between varieties of Phaseolus vulgaris L., and in crosses between this species (O.S.C. 22 Blue Lake) and Phaseolus coccineus L., the runner bean. The present report summarizes the results of limited F_2 tests with the interspecific cross. The results of more extensive studies of the P. vulgaris crosses will be published elsewhere.

Certain genetic differences between P. vulgaris and P. coccineus, the significance of such differences in the evolution of the species, and the characteristics of the interspecific hybrid have been discussed by Lamprecht (3, 4), Tschermak-Seysenegg (9), and Gates (1).

Resistance of the species P. coccineus to BYMV[2] has been reported by several workers. Pierce (6) inoculated plants of this species with the type strain of BYMV in 1934 and indicated that there was no infection. Zaumeyer and Fisher (10), in 1953, found no infection of P. coccineus plants inoculated with a necrotic lesion strain of BYMV described at that time. Thomas and Zaumeyer (8), also in 1953, reported the Streamliner variety of P. coccineus to be resistant to a severe virus strain that produced local lesions on tobacco, and which they classified as BYMV. Rudorf (7) in Germany in 1955, reported extreme resistance of P. coccineus to BYMV. Resistance was transferred to fertile progeny lines of crosses with P. vulgaris.

At this station, six lines of P. coccineus appear to be immune from several strains of BYMV collected in the field in Oregon, and have also proven highly resistant to or immune from naturally transmitted viruses carried in gladioli in the field. Gladioli in Oregon have been reported by McWhorter and co-workers (5) to be carriers of strains of BYMV. In this study they have been found to be good sources of inoculum for the natural infection of susceptible varieties.

MATERIALS AND METHODS

Crosses were made in 1953 between O.S.C. 22 Blue Lake (P. vulgaris) and Accession 2014 (P. coccineus). O.S.C. 22, a uniform breeding line developed from a selection out of the F.M. 1 Blue Lake variety, is a pole type snap bean of high quality. Accession 2014, which was received from E. M. Meader of the University of New Hampshire as Barteldes Lima, is a white flowered, pole type with typical P. coccineus characteristics: vigorous growth, profuse flowering, and large, fibrous, flat pods containing very large seeds. Only crosses using O.S.C. 22 as the pistillate parent succeeded.

The F_1 test for this cross consisted of a field inoculation of six plants (no additional seed was available). Susceptibility in the F_2 population was determined by three separate green-

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[1]Technical Paper No. 974, Oregon Agricultural Experiment Station.

[2]Bean yellow mosaic virus.

house tests. The first, made in December 1954, consisted of a single inoculation of the primary leaves followed by the elimination of all plants that developed visible symptoms during a 6-week period. The remaining tests, made in February and June, 1955, consisted of an initial inoculation of the primary leaves, followed by a second inoculation of trifoliate leaves of all plants that were symptomless after 3 weeks. In 8 to 10 weeks leaf samples were taken from all symptomless plants or from plants with questionable symptoms, and subinoculations were made in the susceptible variety Dwarf Horticultural to determine the presence or absence of the virus.

In 1954, crosses were made between O.S.C. 21, a breeding line similar in type and origin to O.S.C. 22, and five additional distinct lines of P. coccineus which were similar in general characters to Acc. 2014. Among these additional lines were three red-orange flowered types. These crosses are listed in Table 1.

Inoculations were made by rubbing juice from young infected Dwarf Horticultural leaves, at a 5:1 dilution, on leaves that had been dusted with carborundum. Two virus strains, designated as the Y and W strains of BYMV, were used for testing. The Y-strain was isolated by Dr. F. P. McWhorter, of Oregon State College, from a severely infected field of Blue Lake beans in western Oregon. This strain causes considerable pod distortion and/or severe mottle, stunting, and sometimes death of the plant in susceptible varieties. It appears to be similar to the pod-distorting strain of BYMV reported by Grogan and Walker (2). The W-strain, obtained from Dr. Walter Virgin of the California Packing Company, was similar to the Y-strain but slightly more severe in effect.

RESULTS

A high percentage of the O.S.C. 22 or O.S.C. 21 inoculated check plants was severely infected, showing considerable distortion and reduction in size of leaves and stems. Figure 1 shows typical leaf symptoms of these varieties. No symptoms were ever observed in inoculated plants of line 2014, or any of the other P. coccineus lines, when used as resistant checks for progeny tests or in a number of additional inoculations. In several cases subinoculations were made from these inoculated plants to Dwarf Horticultural, but no infection was obtained; the P. coccineus lines were not symptomless carriers.

Table 1 shows the results of limited inoculations of F_1 plants from the crosses involving O.S.C. 21 as the susceptible parent. The data for the two viruses have been combined because of the small total number of plants tested. Symptoms of infected plants were generally mild but distinct, and were similar to the F_2 symptoms shown in Figure 2. These limited data are included to show that the F_1 generation of such crosses may be distinctly susceptible.

No symptoms were observed in the six O.S.C. 22 X 2014 F_1 plants tested in the field. Since subinoculations were not made to determine the presence or absence of the virus, these plants may have been escapes or symptomless carriers.

Infections of O.S.C. 22 X 2014 F_2 plants varied in severity from that of the susceptible parent to a symptomless condition in which the presence of the virus was proven only by subinoculations on Dwarf Horticultural. Symptoms in most F_2 plants were distinct but mild, as shown in Figure 2, with little distortion and reduction of leaf or plant. Many plants, however, developed symptoms which were indistinct and difficult to detect (Figure 3). The range of symptoms was the same for each virus strain, but the W-strain was generally more severe in effect. General necrosis of leaf blades occurred in many plants during spring or summer, but was slightly apparent in winter.

Table 2 presents the numbers of infected versus uninfected plants in the December 1954 test with the W-strain. Tables 3 and 4 show the distribution of symptom types for the February test with the Y strain, and the June tests with the W and Y-strains. In Table 4 the plant numbers for the W and Y inoculations are combined because the results for the two strains were almost identical.

It was not considered feasible to attempt further genetic interpretations of the data presented in Tables 3 and 4 on the basis of symptom groups. Table 5 presents the results of each test, in terms of infected versus uninfected plants, and the tests of these results against possible genetic ratios.

Chi-square values indicate that the data of the June-1955 test fit a 63:1 ratio, while those of previous tests were intermediate between 15:1 and 3:1 ratios. Such differences were possibly due to environmental effects as well as to the procedures employed. The low infection percentage of the first test (Table 2) could probably be expected, because the plants were inoculated only once, and because symptomless plants were not tested by subinoculation to a susceptible variety. In addition, this test was conducted during the winter months when symptom ex-

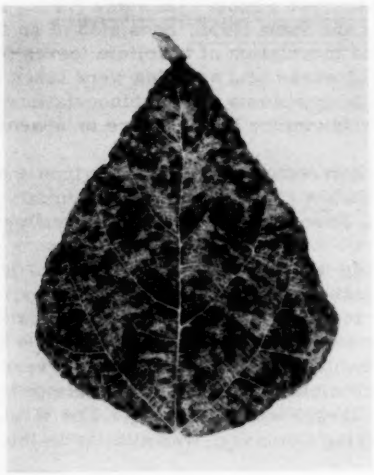

FIGURE 1. Typical leaflet of O.S.C. 22 (Phaseolus vulgaris). infected with the Y strain of BYMV.

FIGURE 2. Mild but distinct infection of an O.S.C. 22 X 2014 (P. coccineus) F_2 plant infected with the Y strain of BYMV.

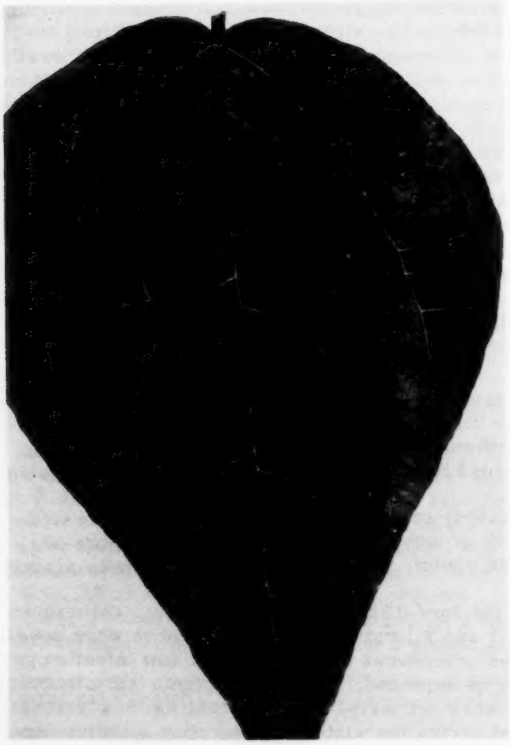

FIGURE 3. Very mild and indistinct infection of an O.S.C. 22 X 2014 F_2 plant infected with the Y strain of BYMV.

Table 1. Susceptibility of the F_1 Generations of O.S.C. 21 (Phaseolus vulgaris) X P. coccineus Lines Tested in 1955 with Strains of BYMV.

Hybrid Combination	Plants Inoculated	Plants Infected
O.S.C. 21 X 2012	1	1
O.S.C. 21 X 2016	1	0
O.S.C. 21 X 2018	2	1
O.S.C. 21 X 2019	4	4
O.S.C. 21 X Scarlet Runner	5	2
Totals	13	8

Table 2. Results of the O.S.C. 22 X (Phaseolus vulgaris) X 2014 (P. coccineus) F_2 Test Made in December, 1954, with the W Strain of BYMV.

Progeny or Check Variety	Plants Tested	Plants Infected	Plants Not Infected
O.S.C. 22 X 2014 F_2	156	134	22
O.S.C. 21[a]	90	89	1
2014	21	0	21

[a]Tested instead of O.S.C. 22 as susceptible check.

Table 3. Results of the February, 1955, Test of O.S.C. 22 X 2014 F_2 Made in Greenhouse Ground-beds with the Y Strain of BYMV.

Progeny or Check Variety	Plants Tested	Infections				Non-infected
		Severe	Mild	Indistinct	Symptomless	
O.S.C. 22 X 2014 F_2	287	16	132	66[a]	40[a]	33[a]
O.S.C. 22	9	8	0	0	0	1
2014	10	0	0	0	0	10

[a]Reaction confirmed by subinoculations to Dwarf Horticultural.

Table 4. Results of the June, 1955, Test of O.S.C. 22 X 2014 F_2 with the Y and W Strains of BYMV.

Progeny or Check Variety	Plants Tested	Infections				Non-Infected
		Severe	Mild	Indistinct	Symptomless	
O.S.C. 22 X 2014 F_2	215	8	194	1 [a]	8 [a]	4 [a]
O.S.C. 22	60	60	0	0	0	0
2014	15	0	0	0	0	15

[a]Reaction confirmed by subinoculations to Dwarf Horticultural.

Table 5. Experimental Ratios of Infected versus Uninfected Plants from F_2 Tests of O.S.C. 22 X 2014.

F_2 Test	Plants Tested	Infected	Uninfected		X^2	P
December 1954	156	134	22	3:1	9.31	<.01
				15:1	14.90	<.01
February 1955	287	254	33	3:1	27.25	<.01
				15:1	12.70	<.01
June 1955	215	211	4	63:1	0.003	.98 - .95

pression has been observed to be less distinct.

Tables 3 and 4 show clearly that many plants without visible symptoms may carry the virus in a concentration sufficient to infect Dwarf Horticultural. In most such cases, Dwarf Horticultural was infected as readily and severely as when visibly infected plants served as an inoculum source, but in a few cases the infection was sufficiently late and mild in appearance to suggest that the F_2 plant contained a very low concentration of virus, or that some modification in the virus had occurred. The F_2 plants were large and vigorous, and in many cases developed thick, very dark green leaves which may have tended to mask the virus effects.

DISCUSSION

The data presented in the tables do not permit exact interpretations of the inheritance of resistance to bean yellow mosaic virus in the interspecific cross. They do, however, permit certain general conclusions which should be useful in practical application. Resistance is apparently recessive, and conditioned by at least two and possibly three major genes. In either case, the continuous variation of the visible symptoms would seem to indicate the effects of modifying genes. The environmental effects, in interaction with the variable genotypes, would explain some of the variability in the number of plants infected in different tests.

It is recognized that the combinations of genes resulting from such an interspecific cross might affect the apparent results in many ways. In general, the F_1 generation was vigorous, uniform, and intermediate in many plant characters. Although flowering was normal, seed

production was much lower than that of either parent, indicating possible genic or cytological incompatibilities. The F_2 generation included a great diversity of plant types with all degrees of fertility.

Rudorf (7) in Germany was unable to determine the inheritance of resistance in the interspecific cross because the F_1 generation was largely sterile. Susceptibility of the F_1 was observed, however. He was able to establish fertile resistant progenies which were to be used for inheritance studies.

Although the use of the interspecific cross involves many problems not encountered in the usual hybridization within Phaseolus vulgaris, it may eventually be necessary to utilize as much as possible the virus resistance in this species for breeding purposes. This may be especially true because of the importance of virus strains in relation to such breeding programs. Although only two strains of BYMV have been used in this study for greenhouse testing, a total of 223 plants of the various P. coccineus lines were grown in the field near infected gladioli. All remained symptomless, although the check varieties were from 50 to 100 percent severely infected by insect-transmitted viruses that produced BYM symptoms. From these results, and from the reports in the literature, it is likely that lines of this species possess very high general resistance to or immunity from a large number of BYMV strains and should be valuable for use in breeding programs.

It should be recognized that the occurrence of symptomless infections must be considered in the formulation of breeding objectives. Although such symptomless or masked conditions may in some cases be related to the tendency of segregates from this cross to be thick-leaved and dark green in color, they may nevertheless occur in advanced generations in a breeding program. It would therefore be necessary to make extensive subinoculations to susceptible varieties in order to avoid the development of tolerant varieties.

Literature Cited

1. Gates, R. R. 1951. Epigeal germination in the Leguminosae. Bot. Gaz. 113: 151-157.
2. Grogan, Raymond G., and J. C. Walker. 1948. A pod-distorting strain of the yellow mosaic virus of bean. Jour. Agr. Res. 77: 301-314.
3. Lamprecht, H. 1945. A new ornamental plant from a cross between the garden bean and scarlet runner, with an elucidation of the species concept. Agri Hortique Genetica, Landskrona 3: 14-32.
4. Lamprecht, H. 1948. On the effect and linkage of genes transmitted from Phaseolus coccineus to P. vulgaris. Agri Hortique Genetica, Landskrona 6: 64-81.
5. McWhorter, F. P., Lytton Boyle, and B. F. Dana. 1947. Production of yellow bean mosaic in beans by virus from mottled gladiolus. Science 105: 177-178.
6. Pierce, Walter H. 1934. Viroses of the bean. Phytopathology 24: 87-115.
7. Rudorf, W. 1955. The transference of resistance to bean mosaic viruses 1 (common bean mosaic) and 2 (yellow bean mosaic) to fertile hybrid plants from the cross P. vulgaris X P. coccineus. Naturwissenschaften 42: 19-20.
8. Thomas, H. Rex, and W. J. Zaumeyer. 1953. A strain of yellow bean mosaic virus producing local lesions on tobacco. Phytopathology 43: 11-15.
9. Tschermak-Seysenegg, E. von. 1942. Hybrids between P. vulgaris and P. multiflorus and their eventual practical use. Züchter 14: 153-164.
10. Zaumeyer, W. J., and H. H. Fisher. 1953. A new necrotic lesion producing strain of yellow bean mosaic. Phytopathology 43: 45-49.

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STUDIES IN THE CONTROL OF BACTERIAL AND FUNGOUS DECAY OF POTATO SEED PIECES

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ABSTRACT

The fungicides Dithane and Dow M-137 were found to be compatible with Streptomycin. Good control of the fungous decay following treatment of seed pieces with Streptomycin was obtained by treating the whole tubers with Dithane, Phygon, and Captan before cutting.

Tests with different antibiotics did not show any to be effective against both bacterial and fungous decay of potato seed pieces. Good control of the fungous rots was obtained with Rimocidin Sulphate alone and in combination with Agrimycin 100.

INTRODUCTION

The treatment of potato seed pieces with solutions containing streptomycin sulphate has proved effective in controlling bacterial decay but has been observed to increase the occurrence of fungous rotting (1). Therefore, some fungicides and antibiotics were tested to determine whether they could be used with the streptomycin to control the fungous decay without reducing the antibacterial activity of the streptomycin. Some antibiotics were also tested to determine their effect on the bacteria and fungi which commonly cause seed-piece decay.

THE USE OF FUNGICIDES WITH ANTIBIOTICS

Compatibility of Dithane and Dow M-137 with Streptomycin -- The compatibility of the fungicides Dithane and Dow M-137 with streptomycin preparations was tested. For this, freshly cut seed pieces were dipped in solutions containing streptomycin or the streptomycin and a fungicide. The treated seed pieces were then inoculated with Erwinia atroseptica or Pseudomonas fluorescens, two common soft-rotting organisms, and incubated in moisture-proof bags. In respect to E. atroseptica decay, the effect of length of storage on the Agrimycin-Dithane combination was also determined by treating seed pieces at daily intervals with the solution for 5 successive days after preparation. The usual control seed pieces were dipped in water instead of in the solutions under test.

The results, given in Table 1, indicate that Dithane and Dow M-137 do not inhibit bacterial decay, and that they do not affect the antibacterial activity of Streptomycin Sulphate and Agrimycin 100[3] when used with them, even up to at least three days after they have been mixed in solution.

Treatment with Fungicides and Antibiotics under Commercial Conditions -- Experiments were set up to determine the disease controlling effect of certain fungicides and Agrimycin 100 when used together in treating seed potatoes. It had been observed that fungicides which were successful in controlling potato fungous decay commonly injured the cut surfaces if used on freshly cut seed pieces; therefore, in the experiments the fungicides were used to treat whole tubers prior to cutting and treating with the antibiotic.

Whole Katahdin tubers were treated with Dithane (2 qts./100 gal.), Captan[4] (2 lbs./100 gal.) or Phygon[5] (2 lbs./100 gal.) cut into seed pieces, and dipped in a solution of Agrimycin 100 (100 p.p.m.). For comparison, some tubers were treated in the respective fungicides but after cutting no Agrimycin treatment was given. Others received no treatment with either fungicide or antibiotic.

After 2 weeks all the seed pieces were in good condition. Two months after treatment the seed pieces, except the untreated controls and the series treated with Phygon alone, had a good appearance; however, the Phygon treated series then showed 4 percent Fusarium rot while 44

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2 Plant Pathologist, Maine Agricultural Experiment Station.

3 Agrimycin 100 is a product of Chas. Pfizer & Co., Inc., containing Streptomycin and Terramycin as active ingredients.

4 Captan is N-trichlormethylmercapto-4 cyclohexene-1:2-dicarboximide, a product of California Spray-Chemical Corp.

5 Phygon (dichlone) is Dichloronaphthoquinone, a product of Naugatuck Chemical.

FIGURE 1. The treatment of potato seed pieces with Rimocidin Sulphate. Left--Rimocidin Sulphate treated seed pieces showing a good mould-free appearance four weeks after inoculation. Right--Untreated seed pieces showing considerable growth of surface mould.

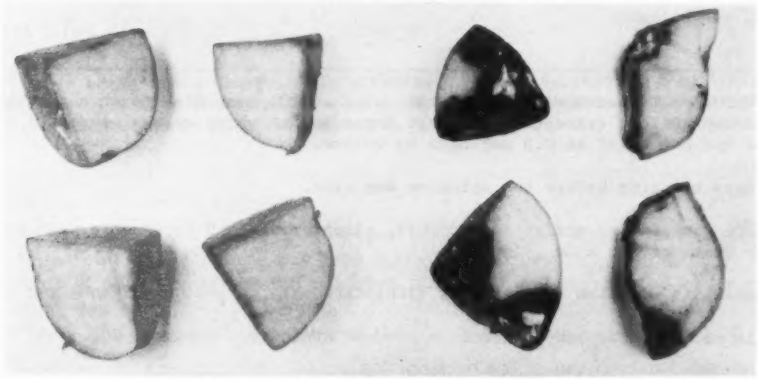

FIGURE 2. The treatment of potato seed pieces with Rimocidin Sulphate. Left--Seed pieces treated with Rimocidin Sulphate cut to show no penetration of decay organisms on the treated surfaces. Right--Untreated seed pieces cut to show the normal seed-piece decay.

Table 1. Effect of fungicides on Streptomycin.

Treatment[a]	Time[b]	Seed piece rotting (per cent) following inoculation with	
		Erwinia atroseptica	Pseudomonas fluorescens
Streptomycin sulphate	0	0	0
Streptomycin sulphate and Dithane	0	0	0
Streptomycin sulphate and Dow M-137	0	0	0
Agrimycin 100[c]	0	0	0
Agrimycin 100 and Dithane	0	0	0
Agrimycin 100 and Dow M-137	0	0	0
Dithane[d]	0	100	100
Dow M-137[e]	0	100	100
Water	0	100	95
Agrimycin 100	3	Trace	
Agrimycin 100	4	25	
Agrimycin 100	5	15	
Agrimycin 100 and Dithane	3	Trace	
Agrimycin 100 and Dithane	4	23	
Agrimycin 100 and Dithane	5	38	

a Streptomycin sulphate and Agrimycin 100 were used at 100 ppm, Dithane at a concentration of 2 quarts/100 gallons (except in the last three series where it was used as 1 pint in 30 gallons) and Dow M-137 at 0.5 per cent by volume.

b Number of days elapsing before the solution was used.

c Agrimycin 100 contains as active ingredients, streptomycin and terramycin, and was supplied by Chas. Pfizer & Co., Inc.

d Dithane (nabam) is disodium ethylene bis dithiocarbamate, a product of Rohm and Haas Co.

e Dow M-137 is sodium orthophenyl phenol, a product of the Dow Chemical Co.

percent Fusarium rot was evident in the controls. Since no rot occurred in the treated seed pieces treating whole tubers with a fungicide before cutting is apparently effective in controlling the fungous decay associated with treating seed pieces in Agrimycin.

ANTIBIOTICS

Various antibiotics considered effective in controlling plant diseases were tested to determine their ability to control seed-piece decay. Preliminary tests were made on potato slices, and the more promising antibiotics were then used to treat potato seed pieces.

Slice Tests -- Slices, about half an inch thick, were cut from surface sterilized potatoes, dipped for 5 minutes in the test solutions, and placed in sterile petri dishes. The slices were then inoculated with E. atroseptica, E. carotovora, Fusarium caeruleum, or Phoma tuberosa

Table 2. Tests with antibiotics against bacteria and fungi on potato slices.

Antibiotic[a]	Reaction[b] with			
	Erwinia carotovora	Erwinia atroseptica	Fusarium caeruleum	Phoma tuberosa
Filipin (33% purity)	+	+	+	+
Filipin (94% purity)	+	+	+	±
Albamycin	+	+	±	+
Oligomycin	+	+	-	-
Agrimycin 100	-	-	+	+
P88	-	-	+	±
PA106	d	d	d	d
Rimocidin sulphate	+	+	±	±
Neomycin[c]	-	-	+	+
Phytomycin	-	-	+	+
Water	+	+	+	+

a Filipin and Albamycin were supplied by the Upjohn Co., Phytomycin by Olin Mathieson Chem. Corp., and the remainder by Chas. Pfizer & Co., Inc. All used at 200 p.p.m.

b - no infection
± slight necrosis at point of inoculation
+ pronounced infection
d damage due to antibiotic

c In these tests Neomycin was effective against bacterial decay but consistent results were not obtained when different preparations of this antibiotic were tested in other experiments.

With the bacteria, half-inch squares of paper towelling were dipped in a suspension of the respective organisms and a square was then placed on the centre of the slice to be tested. Small uniform discs of agar and mycelium cut from plate cultures were used as inoculum for the fungi; each slice was inoculated by placing a disc of the appropriate inoculum on it. Eight replications of each inoculation were made and the slices were kept at about 70° F. under moist conditions.

Table 2 lists the antibiotics tested and indicates where rotting occurred with the respective organisms. The results when the bacteria were used were recorded after 3 days while those with the fungi were taken after 3 weeks' incubation.

Agrimycin 100, P88, Neomycin, and Phytomycin were found to give good control of the bacteria while Oligomycin and Rimocidin Sulphate were the most effective against the fungi. None of the antibiotics were found to inhibit the growth of both the fungi and bacteria.

Further Slice Tests with Rimocidin Sulphate -- Further slice tests were made using different concentrations of Rimocidin Sulphate. Since this antibiotic was not found to be effective in controlling the soft-rot organisms a parallel series of tests was made using Rimocidin Sulphate with Agrimycin 100.

Solutions containing 10, 25, 50, and 100 p.p.m. respectively of Rimocidin Sulphate, and a similar series of solutions containing, in addition, 200 p.p.m. Agrimycin 100, were prepared. Slices cut from surface sterilized potatoes were treated in the solutions and inoculated in the same way as in the slice tests above. Fusarium caeruleum, F. sambucinum f. 6 and two

Table 3. Treatment of potato seed pieces with antibiotics.

Treatment[a]	Condition of seed pieces inoculated with	
	Fusarium sambucinum	Phoma tuberosa
Rimocidin sulphate 100 p.p.m.	Good	Good
Rimocidin sulphate 200 p.p.m.	Good	Good
Rimocidin sulphate 100 p.p.m. and Agrimycin 100 200 p.p.m.	Good	Occasional shallow spots
Rimocidin sulphate 200 p.p.m. and Agrimycin 100 200 p.p.m.	Good	General superficial necrosis
Oligomycin 100 p.p.m.	General superficial necrosis	General superficial necrosis
Oligomycin 200 p.p.m.	General superficial necrosis	Extensive decay
Oligomycin 100 p.p.m. and Agrimycin 100 200 p.p.m.	General superficial necrosis	General superficial necrosis
Oligomycin 200 p.p.m. and Agrimycin 100 200 p.p.m.	General superficial necrosis, some deep	Extensive decay
Agrimycin 100 200 p.p.m.	Occasional shallow spots	General superficial necrosis
Water	Occasional shallow spots and deep rots	General superficial necrosis

a Oligomycin apparently had a phytotoxic effect and this probably accounts for the decay associated with the use of this antibiotic.

strains of Phoma tuberosa were used as inoculum and the slices were incubated at 43° F. for three weeks.

At the end of the incubation period only a slight necrosis in the region of the inoculum was observed in the Rimocidin Sulphate treated slices. However, rotting was more extensive, in depth and surface area, where the Rimocidin Sulphate and Agrimycin had been used together, particularly among the slices inoculated with Phoma. The most extensive rotting was in the control slices treated with water or Agrimycin alone, especially in the case of the latter.

Seed Piece Tests -- The antibiotics used in the slice tests were also used to treat seed pieces against fungous decay. Mycelial suspensions of F. caeruleum and P. tuberosa, prepared by macerating plate cultures of each of these fungi in a blender, were used as inoculum. Freshly cut seed pieces were dipped in the Fusarium or Phoma suspension, then sprayed with the respective antibiotics listed in Table 2. Twenty seed pieces were used for each treatment and were stored in polyethylene bags at 40° F. for 4 weeks.

The seed-piece inoculations gave approximately the same results as the slice tests except that severe decay ocurred in the Oligomycin series. The decay was mainly due to bacteria but there was some indication, in this and other experiments, that the Oligomycin had damaged the potato tissue. The seed pieces treated with Rimocidin Sulphate had a good appearance and were free from the rot and superficial mould which commonly occurs after treatment with antibiotics. (Figures 1 and 2.)

Further Seed-Piece Tests with Rimodicin Sulphate and Oligomycin -- Additional seed-piece tests were carried out using Rimocidin Sulphate and Oligomycin, and these antibiotics with Agrimycin 100. Freshly cut seed pieces were dipped in a mycelial suspension of F. sambucinum or P. tuberosa and then in the appropriate antibiotic solution. The control series, dipped in Agrimycin 100 or water, were treated in the same way. Ten seed pieces per treatment were

used and each treatment was replicated five times. The treated seed pieces were stored in polyethylene bags at 45° F.

Observations, made after 3 weeks (Table 3) indicated that Rimocidin Sulphate gave good control of the Fusarium and Phoma at both 100 and 200 p.p.m. When the treating solutions contained both Rimocidin Sulphate and Agrimycin 100, no Fusarium rot occurred but a very small amount of superficial spotting of the cut surfaces took place with the Phoma. In all the treatments with Oligomycin there was evidence of a toxic effect, and in most cases soft rot set in.

Literature Cited

1. Bonde, Reiner and Jean F. Malcolmson. 1956. Studies in the treatment of potato seed pieces with antibiotic substances in relation to bacterial and fungous decay. Plant Dis. Reptr. 40: 615-619.

MAINE AGRICULTURAL EXPERIMENT STATION

EFFECTS OF ORGANIC FUNGICIDES AND ANTIFUNGAL ANTIBIOTICS ON MUSHROOM MILDEW, DACTYLIUM DENDROIDES AND LIPSTICK MOLD, GEOTRICHUM SP.[1]

Robert N. Goodman[2]

Summary

Organic fungicides Terraclor and Dowicide A, and antifungal antibiotics Actidione, Anisomycin, Griseofulvin, Rimocidin, and Oligomycin were applied as drenches to mushroom beds for control of "mildew", Dactylium dendroides. Terraclor at either 500 or 1000 ppm proved highly effective in controlling "mildew". In addition, this material was found to be equally effective against "lipstick" mold, Geotrichum sp.

During the past two years a series of experiments have been in progress in an effort to to control "mildew" of mushrooms, causal organism Dactylium dendroides.

The investigations described herein were conducted in a commercial establishment at Hermann, Missouri. The physical plant had previously been a winery, the underground cellars of which have been adapted to the production of mushrooms. The installation is one of the best in Missouri and is isolated from other producing areas, being 100 miles from the nearest commercial plant.

Previous history of Dactylium in the houses has been erratic with respect to general severity and occurrence in a given house.

The disease first became evident in January of 1955 and reached epiphytotic proportions by late February. In some of the affected houses production was prematurely curtailed (Fig. 1)

The preparations used in the experiments were:

Acti-dione (cycloheximide), produced by the Upjohn Company, Kalamazoo, Michigan.
Acti-dione in aerosol bombs at concentrations of 1 % and 0.5%. The bombs also contained 7% acetone, 7% Velsicol, 2 pounds methyl chloride (CH_2Cl), and were formulated by Dr. Wm. Klomparens of the Upjohn Company. The aerosol was dispensed at the rate of 4 seconds per 1000 cubic feet.
Anisomycin, Rimocidin, Oligomycin, produced by Charles Pfizer Co., Brooklyn, New York.
Griseofulvin, produced by Merck & Co., Rahway, New Jersey
Terraclor (pentachloronitrobenzene), produced by Olin Mathieson Chemical Company
Dowicide A (O-phenyl phenol, sodium salt), produced by Dow Chemical Company.

In the first experiments, set up in March 1955, Acti-dione was applied as a bed drench at 2.6 ppm and as an aerosol. The aerosol did not appear to be effective; however, the bed-drench appeared to stop the surface growth of the pathogen and inactivated it in those areas where growth was already evident. Approximately 2 weeks after the Acti-dione was applied warm weather ensued and the disease in the untreated check areas halted its migration across the surface of the beds and no new outcroppings of mycelial growth developed. It was therefore impossible to determine specifically whether the Acti-dione had been effective in preventing new growth of the fungus. It was obvious, however, that the antibiotic drenches had inactivated established mycelial pads of Dactylium.

During the current growing season mildew became evident in mid-March. Replicated plots were set up employing the following antibiotics: Acti-dione, 2.6 ppm; Anisomycin, Griseofulvin, Rimocidin, and Oligomycin, all at 100 ppm. The antibiotics were applied as bed drenches through the conventional watering apparatus.

Each antibiotic was applied to 4 separate patches of mildew and immediate surrounding area. The individual plot size was approximately 9 square feet. Numerous untreated mycelial

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[1]Journal Series Paper No. 1641 approved by the Director of the Missouri Agricultural Experiment Station.

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mats in the beds where the antibiotics were applied served as controls. From these treatments it was possible to detect (a) the lethal effect of the antibiotic on the established patch of mildew, (b) the degree of spread from the original site, and (c) the occurrence of new surface growth within the confines of the treated area.

Results of this experiment are summarized below:

(a) Acti-dione and Anisomycin inactivated established areas of Dactylium for about 10 days.
(b) Following this 10-day period the fungus resumed growth in the original site and also in the surrounding treated area.
(c) Rimocidin, Griseofulvin, and Oligomycin were not effective.
(d) No phytotoxic effects were observed on the mushrooms coming up in the treated areas or on mushrooms present at the time of treatment.

These results led to a second experiment wherein replicated plots of 25-foot lengths of mushroom bed were treated with Acti-dione and Anisomycin at 2.6 and 100 ppm respectively. By this time the pathogen had become exceedingly active and was spreading rapidly over the beds.

Again Acti-dione and Anisomycin were observed to afford only temporary inactivation of the pathogen. Repeated applications, at weekly intervals, of these partially effective antibiotics were planned; however, this procedure was abandoned in view of the recent report of Stoller, West and Bailey (1).

The excellent results obtained by Stoller et al. prompted the use of Terraclor and Dowicide A. When this third experiment was initiated the disease was rampant in beds that had just been reloaded and which had yielded over one pound per square foot in the first two breaks. Dactylium was equally as intense in recased beds, containing exceedingly active spawn and from which no breaks had yet been harvested.

The two organic fungicides were applied to triplicated 30-foot lengths of mushroom bed at concentrations of 1000 ppm and 500 ppm.

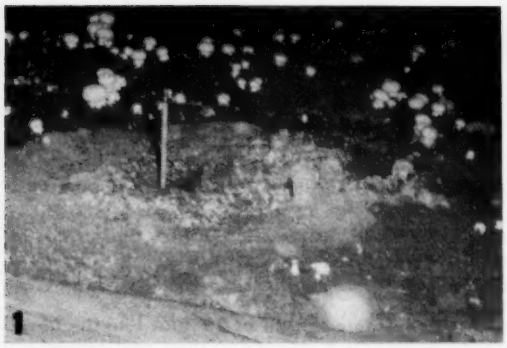
The following is a summary of the results from the Terraclor treatments:

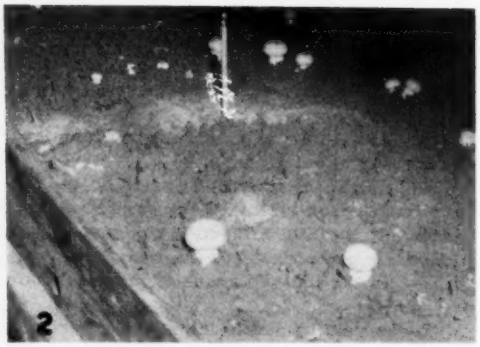
(a) At either 500 or 1000 ppm the established mats of Dactylium were inactivated - as evidenced by the collapse of the mycelial tufts (Fig. 2)
(b) As a result of a single application only occasional new growth of mildew developed in the treated area during the succeeding 6-week period that the beds were cropped.
(c) The new mats that appeared were small and did not spread. In addition, an occasional mushroom had Dactylium on its cap and stalk and in these instances the mycelial growth did not extend to the casing soil.
(d) These isolated appearances of the pathogen in treated beds were attributed primarily to poor coverage. It is believed that best results were obtained where the casing soil was wet to a depth of at least 1/2 inch with the 1000 ppm concentration.
(e) No phytotoxicity was observed at either concentration.
(f) Although yield data were not obtained there appeared to be no unusual reduction in yield in the treated beds.
(g) Despite treatment, mushrooms failed to form where Dactylium had been present.

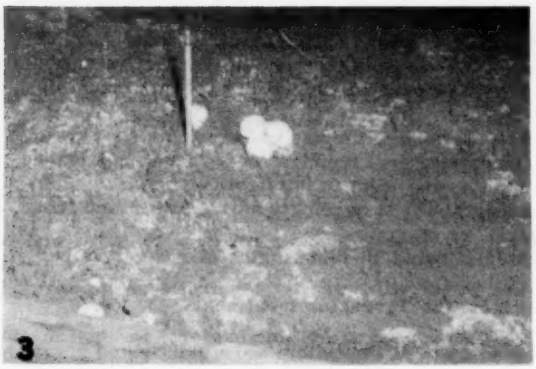
The following is a summary of results obtained with Dowicide A.

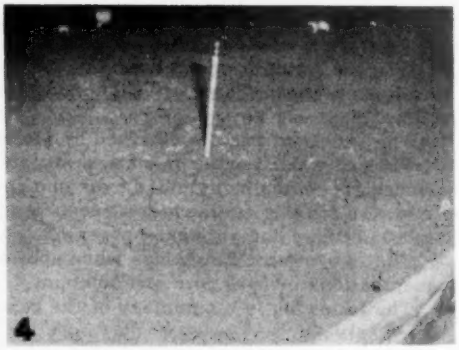
(a) The single application of this material at 500 and 1000 ppm inhibited further development of Dactylium for about the same length of time recorded for Acti-dione and Anisomycin.
(b) Mushrooms that broke through the casing soil of the Dowicide A-treated plots showed an undesirable brown discoloration.
(c) This phytotoxicity was apparent at both concentrations and was evident the day following the application.

As it became evident that the results with Terraclor reported by Stoller and his associates were being duplicated, this material was applied at 1000 ppm to all houses still in production. Many of these houses were showing the disease by this time in various degrees of intensity. The results of these final applications were in all instances highly effective in controlling Dactylium









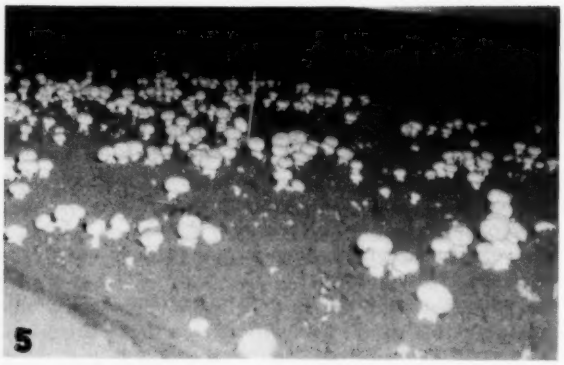


FIGURE 1. Dactylium dendroides in an untreated bed. FIGURE 2. Patches of Dactylium inactivated by Terraclor at 1000 ppm. Photograph was taken 4 weeks after treatment. FIGURE 3. Lipstick mold, Geotrichum sp, in untreated bed. FIGURE 4. Lipstick mold which appeared on a recased bed prior to first break of mushrooms and which was treated with Terraclor before the mold had matured FIGURE 5. A recased bed which was treated with Terraclor at 1000 ppm and which had exhibited numerous patches of Dactylium prior to recasing. Photograph was taken 4 weeks after treatment.

dendroides.

Of additional interest was the observation that a fungus, Geotrichum sp., commonly referred to as "lipstick mold" was effectively controlled by Terraclor. Lipstick mold has been present in the houses where these studies were conducted for the past 2 years and has also been observed in mushroom houses of the Kansas City area. It is a weed fungus which restricts its growth to the surface of the casing soil, and in the fruiting stage it takes on a characteristic red coloration from which its name is derived. When this mold first appears on the bed surface it is quite similar to mushroom spawn. It has also been noted that wherever this mold is present, mushrooms fail to break through the casing soil (Fig. 3).

Geotrichum appeared at about the time when all houses still in production were being routinely treated with Terraclor. Soon thereafter it became evident that Terraclor was effective not only against mildew but also controlled lipstick mold as well. From limited observations only, there is some reason to believe that if this fungus is inactivated shortly after it appears on the beds it does not seriously effect "break through" of mushrooms (Fig. 4, 5).

It may also be added that during the past cropping season sodium hypochlorite was routinely added to the water applied to the beds. The concentration used was 100 ppm, as suggested by Ayers and Lambert (2). The occurrence of Dactylium dendroides in epiphytotic proportions and more than occasional growth of lipstick mold support the conclusions of Ayers and Lambert that chlorinated water has little or no effect upon these two mushroom pathogens.

Literature Cited

1. Stoller, B. B., R. E. West, and J. F. Bailey. 1956 Controlling the mildew disease of the cultivated mushroom. Plant Dis. Reptr. 40: 193-199.
2. Ayers, T. T., and E. B. Lambert. 1955. Controlling mushroom diseases with chlorinated water. Plant Dis. Reptr. 39: 829-836.

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PROGRESS IN THE CONTROL OF GRAY MOLD OF TOMATO IN SOUTH FLORIDA[1]

R. S. Cox and N. C. Hayslip[2]

Abstract

Dichlone and ferbam showed an effective degree of control of gray mold on tomato foliage in repeated experiments; Vancide 51, Tennam, and thiram exhibited excellent control in the one experiment in which they were tested. Evidence showed that repeated spraying with nabam (plus metal salts), and possibly other ethylenebisdithiocarbamate materials, resulted in increased gray mold incidence on stems, leaves and fruit. Dichlone appeared to offset this effect when used in mixture with nabam-zinc sulfate. Nabam caused from light to moderate leaf chlorosis depending upon the metal salt(s) used. Dichlone caused injury when applied on hot days. Phytotoxicity was intensified when dichlone and nabam-zinc sulfate were used in mixture. Tennam caused slight, and Vancide 51 moderate, foliar injury. Significant yield reduction was noted in plots sprayed with the following: Dithane D-14 plus zinc sulfate, Terraclor, Tennam, and Vancide 51. Fruit rots were significantly higher in three of the four nabam-metal salt treatments than in the check. Several materials showed a degree of control of Rhizoctonia fruit rot. The high yield in the thiram-sprayed plots was attributed to control of gray mold (foliar and fruit) and Rhizoctonia fruit rot, in the absence of phytotoxicity.

Darby[3] has shown that gray mold (Botrytis cinerea Pers. ex. Fr.) became a serious problem on tomatoes in south Florida following World War II. Prior to that time it was of minor importance. Interestingly, the disease appears to be as severe on staked as on unstaked tomatoes. On staked tomatoes, the upper (younger) portion of the plant is almost as susceptible to the disease as the lower portion (Fig. 1) -- an observation that does not support the conception that the causal organism is a "weak" parasite.

Two problems of paramount importance from the practical viewpoint existed: (a) the reason for the sudden transformation of an obscure disease to a position of great economic importance, and (b) the development of an efficient control program.

Darby[3] found that of several materials tested, only dichlone (Phygon) showed any appreciable degree of control. He obtained a paradoxical situation in which the effective material was only as good as the untreated check. He explained this result on the basis that defoliation in the check plots due to gray leaf spot (Stemphylium solani Weber) created a situation unfavorable for gray mold (B. cinerea).

The following year[4], however, dichlone was reported as "a failure to control" the disease. This report cast the shadow of uncertainty on Darby's interpretation of his results. Our work during the past season (1955-56) has thrown some additional light on both aspects of the problem: i.e., the reason for increased importance of the disease, and a means of effective control. This information introduces the possibility of a different interpretation of Darby's data, and has perhaps paved the way for the ultimate solution of the Botrytis problem.

MATERIALS AND METHODS:

The evaluation of a spray program against a foliar disease of the tomato is generally complicated by the presence of at least one, possibly four, other diseases. Thus, a variety resistant to the diseases other than the one in question would be desirable.

In the present work, the complexity of the problem was considerably alleviated through the use of the variety, Manalucie, which is practically immune from gray leaf spot and moderately resistant to early blight (Alternaria solani (Ell. & G. Mart.) Sor.).

Concurrent experiments were done at Rauth's Farms, Delray Beach (staked tomatoes), and Indian River Field Laboratory, Ft. Pierce (ground tomatoes).

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1 Florida Agricultural Experiment Station Journal Series, No. 501.

2 The writers are indebted to Rauth's Farms, Delray Beach, Florida, for providing facilities for much of this work.

3 Darby, J. F. 1955. A progress report on gray mold and ghost spot of tomatoes and their control. Plant Dis. Reptr. 39: 91-97.

4 Anonymous. Guide for Control of Diseases and Insects of Commercial Vegetables in Florida, 1955-56. Agriculture Extension Service, University of Florida.

At Rauth's Farms, materials were applied with a commercial sprayer delivering 300 p.s.i. The amount of spray applied ranged up to 200 gallons per acre, depending on the size of the plants. A special spray rig was employed at Ft. Pierce (see below).

EXPERIMENTAL PROCEDURE AND RESULTS:

Experiment 1 (Rauth's Farms, Delray Beach): Four-acre plots were treated as follows: Each plot was sprayed with the regular fungicides (alternating zineb, maneb, and tribasic copper sulfate on a 5-day schedule -- hereafter referred to as the alternating schedule). Starting December 16, one-half of each 4-acre plot received one of the test materials. The alternating program was maintained on both halves of each plot. The half on the alternating program only, which served as the adjacent check, appears in Table 1 immediately below the test material used in the same plot in which it occurred. Fifteen applications of the test materials were made from December 16 through February 4. Results are shown in Table 1.

Table 1. Gray mold development on staked tomatoes as affected by various combinations of materials. Rauth's Farms, Delray Beach, 1955-56.

Treatment[a]	Concentration in 100 gals.	Gray Mold		
		Jan. 26[b]	Feb. 3[c]	Feb. 10[c]
Phygon + a.p.	3/4 lb.	134	2.0	3.8
Check (a.p.)	---	399	3.6	5.3
Fermate + a.p.	4 lbs	323	3.0	4.8
Check (a.p.)	---	866	5.1	6.6
Tribasic Copper Sulfate + a.p.	4 lbs.	660	3.6	5.6
Check (a.p.)	---	1043	5.0	6.7
Orthocide 50-W + a.p.	4 lbs.	199	3.5	4.6
Check (a.p.)	---	429	4.3	5.3
Terraclor + a.p.	1 1/2 lbs.	368	4.3	6.0
Check (a.p.)	---	530	4.8	6.1
Dithane D-14 + $ZnSO_4$ + $CuSO_4$ + a.p.	2 qts. -1/4 lb. -3/8 lb.	103	3.5	5.0
Check (a.p.)	---	317	4.3	5.3

[a] a.p. denotes alternating program (see text).
[b] Number of sporulating lesions on 300 ft. of row (mean of three rows).
[c] Scored on a 0-11 basis where 11 equals complete defoliation (mean of four rows).

It is apparent that plots sprayed with dichlone (Phygon) had the lowest disease incidence. However, by comparing with the adjacent check, control in the ferbam (Fermate) sprayed plot appeared to be just as good as that in the dichlone plot. This was believed to be the more accurate comparison because of the variability of disease incidence as exhibited by the check plots. Tribasic copper sulfate and captan (Orthocide 50-W) also showed some indication of control. None of the materials was noticeably phytotoxic. Yield data were not obtained.

Experiment 2 (Rauth's Farms, Delray Beach): Plots comprised 4 acres each. All plots were on the regular alternating program until first fruit set (mid-February). At that time the test fungicides were substituted for the alternating program. Thus each plot was sprayed with maneb (Dithane M-22), zineb (Dithane Z-78) and tribasic copper sulfate on an alternating 5 day schedule until mid-February, and with one of the test materials (dichlone, captan, or zineb) only thereafter. Botrytis gray mold was uniformly distributed through the plots (natural infection) by the mid-February date. Its subsequent development is shown in Table 2.

Dichlone showed a marked degree of control (Fig. 2, Table 2). Although gray mold built

FIGURE 1. Botrytis development on: A -- Plants sprayed with captan. Note denseness of foliage. B -- Plants sprayed with zineb. Note sparseness of foliage. Photographed by Henry M. Spelman III.

FIGURE 2. General view of Experiment No. 2 layout showing:
A -- Captan plot.
B -- Zineb plot. Note sparseness of these rows.
C -- Dichlone plot.

Photographed by Henry M. Spelman III.

FIGURE 3. Dichlone leaf injury. Chlorotic leaf (left); severe marginal leaf burn (right). Photographed by Henry M. Spelman III.

Table 2. Effect of various fungicides on gray mold on staked tomatoes. Rauth's Farms, Delray Beach.

Treatments[a]	Gray mold[b]				Phytoxicity
	Mar. 7	Mar. 14	Mar. 21	Mar. 30	
1. Phygon followed by Orthocide	2.0	2.0	2.0	3.5	Moderate
2. Dithane Z-78	4.0	5.0	5.5	6.5	None
3. Orthocide 50-W	2.0	3.0	3.0	4.0	Trace
4. Phygon	1.0	1.0	2.0	2.0	Moderate

[a] Rates same as shown in Table 1. All four plots were on the alternating program (see text) through mid-February at which time the treatments listed were begun.
[b] Scored on a 0-11 basis where 11 equals complete defoliation.

up in the captan plot, there was considerably less there than in the zineb plot (Figs. 1 & 2, Table 2).

One application of dichlone applied between March 14 and March 21 caused a marked firing (chlorosis followed by necrosis, Fig. 3) of the leaves. This was the only clear-cut case of dichlone injury in the test plots at Rauth's Farms. It was believed to have been tied in with high temperature (above 80° F) at time of application. Because of this injury, plot # 1 was switched from dichlone to captan. Further progression of injury was not observed, however. Disease developed more rapidly in plot # 1 than in plot # 4 following this change, thereby providing additional evidence as to the effectiveness of dichlone. Yield data were not obtained.

Experiment 3, Indian River Field Laboratory, Ft. Pierce: The randomized block design (four replications) comprised single, 32-foot-row plots with a guard row between each. The transplants, set out January 24, were spaced 24 inches apart. Row spacing was 7 feet. The tomatoes were not staked.

Materials were applied by means of a specially-constructed hand boom attached to a power sprayer developing 300 p.s.i. Half of each guard row was sprayed with the test material used on the adjacent plot row. Depending on the size of the plants, the number of nozzles per row ranged from 3 to 10, with a corresponding gallonage-per-acre range of 75 to 250.

The two dust materials were applied at the rate of 25 to 75 pounds per acre with a rotary-type hand duster. The dusts were applied usually to dry plants at mid-day. Moderate winds prevailed during many of the periods of application, thereby preventing good coverage. It should also be noted that the ferbam dust was poorly mixed. These points should be considered when interpreting results.

Eighteen fungicide applications were made during the period February 2 to May 2. In one treatment, Agri-Strep was applied through March 19 (10 applications), when it became evident that bacterial spot would not be a factor and maneb was substituted for the antibiotic.

On February 20, two plants in each guard row were sprayed with a water suspension of Botrytis spores; a second inoculation was made on the night of February 23. As a result, the disease became uniformly established throughout the plots. The incidence remained low, however, because of the prevailing dry weather.

Plots were scored for disease incidence and foliage density on April 25, and again for disease incidence on April 28. For the disease ratings, six areas in each plot were examined by lifting the vines and visually inspecting for sporulation. On April 25, scoring was done on a plus or minus basis. If sporulation occurred, a score of 1 was recorded; 0, if none was found. Thus, the maximum reading for any one treatment on that date was 6.

Because of a 1 1/2-inch rain on April 26, the disease had progressed considerably by April 28. At that time plants were scored on a 0-6 basis, depending on the amount of sporulation observed. A score of 6 denoted many infection loci, plus considerable sporulation on dead plant refuse on the ground. Under such conditions, lifting of the vines was accompanied by a rising "cloud of spores" visible to the naked eye. The maximum possible score for any single plot was 36. A zero score denoted no visible sporulation. The foliage density rating was made on a 0-3 basis where 3 denoted maximum density as determined visually. Results of all three readings are shown in Table 3.

An unexpected result was the highly significant increase in gray mold in plots sprayed with nabam (plus any combination of the metal salts used) over that of the unsprayed check. The only other treatment in which the disease incidence exceeded that of the check was the abbreviated (8-application) maneb program.

Another equally important result was the high degree of control obtained with several materials. Not one instance of sporulation was observed in plots sprayed with Vancide 51, and only one in plots sprayed with Tennam. Ferbam (spray), dichlone (spray or dust), and thiram (Thylate) also showed a high degree of control.

All of the nabam-sprayed plots showed at least some leaf chlorosis. A slight transitory injury was noted in the dichlone plots on one date. Greatest injury occurred in plots sprayed with nabam-zinc sulfate in mixture with dichlone. Tennam and Vancide 51 also caused noticeable foliar injury. In general, plant density was correlated with phytotoxicity.

Contrary to the data in Tables 1 and 2, neither tribasic copper sulfate nor captan showed any degree of control in experiment 3.

Gray mold incidence was not great enough to cause significant yield reduction, except possibly in the nabam plots. Four materials -- nabam (Dithane D-14) + zinc sulfate, Terraclor, Tennam, and Vancide 51 -- reduced yield, apparently through phytotoxic action.

Fruit rot was due primarily to Botrytis cinerea and to Rhizoctonia solani Kuehn (ground rot[5]). Most of the fruit rot in all plots except those treated with nabam was attributed to R. solani, whereas at least half the fruit rot in the nabam plots was caused by B. cinerea.

[5] Ground rot is a serious disease of tomatoes in south Florida, and is an important reason why the industry searches for new land each year.

Table 3. Effect of various materials on disease incidence, plant density, and yield of unstaked tomatoes. Indian River Field Laboratory, Ft. Pierce. (Footnotes on page 725)

Treatment[a]	Concentration (amount in 100 gals., ppm, or % dust)	Disease Incidence Apr. 25[b]	Disease Incidence Apr. 28[b]	Plant Density Apr. 25[b]	Foliar injury[c]	Yield 60 lb. crates /A	Number Rotted fruit[d]
Check	-----	2.0	10	2.8	0.0	500	30
Dithane D-14 + $CuSO_4$ + $ZnSO_4$	2 qt.-3/4 lb.-1/4 lb.	5.7	23	2.8	1.3	452	62
Dithane D-14 + $FeSO_4$ + $ZnSO_4$	2 qt.-5 oz.-3/8 lb.	5.2	20	2.5	0.8	476	38
Dithane D-14 + $FeSO_4$	2 qt.-10 oz.	5.0	20	3.0	1.4	444	65
Dithane D-14 + $ZnSO_4$	2 qt.-3/4 lb.	5.0	24	2.3	1.8	396	57
Dithane D-14 + $ZnSO_4$ + Phygon	2 qt.-3/4 lb.-3/4 lb.	2.7	9	2.5	3.0	478	32
Tribasic Copper Sulfate	4 lb.	3.5	11	3.0	0.0	417	36
Orthocide 50-W	3 lb.	1.8	9	3.0	0.3	505	14
Griseofulvin	440 ppm	2.0	9	2.8	0.3	419	16
Terraclor	2 lb.	1.6	7	2.5	0.3	379	42
Merck Fungicide # 55R5397	1000 ppm	2.2	11	2.3	0.3	438	40
Agristrep, then Manzate	200 ppm-1 1/2 lb.	4.2	13	3.0	0.0	498	39
Fermate (Dust)	9.5%	1.7	7	2.8	0.0	444	22
Fermate (Spray)	4 lb.	0.0	1	3.0	0.0	416	17
Phygon (Dust)	1%	1.8	4	3.0	0.0	458	48
Phygon (Spray)	1/2 lb.	0.5	2	3.0	0.5	443	36
Phygon (Spray)	3/4 lb.	0.5	3	3.0	0.3	499	29
Thylate	1 1/2 lb.	1.0	3	3.0	0.0	532	10
Tennam	2 qt.	0.0	0.2	3.0	0.5	369	15
Vancide 51	2 qt.	0.0	0.0	3.0	1.5	285	19
L.S.D. .05	-----	1.6	6	0.3	0.5	87	24
.01	-----	2.1	8	N.S	1.0	115	32

DISCUSSION

The correlation of high gray mold incidence with all four nabam-metal salt treatments makes possible considerable speculation.

Owing to the resistance of the Manalucie variety to gray leaf spot and early blight, and to the fact that the 1955-56 season was unfavorable for the development of bacterial spot (Xanthomonas vesicatoria (Doidge) Dows.) and late blight (Phytophthora infestans (Mont.) DBy.), the role of defoliation as a factor in gray mold incidence in this experiment was negligible. It would appear, therefore, that a significant increase in gray mold in any plot over that of the check could be attributed in some manner to the material applied.

Immediately the question arises as to whether this apparent phenomenon of a carbamate fungicide increasing incidence of gray mold is restricted to nabam, or whether it includes others in the group. Examination of Tables 1, 2 and 3 shows that zineb and maneb may have an effect (Tables 1 and 2) similar to that of nabam. All of these, of course, are of the ethylenebisdithiocarbamate series. However, materials of the methyldithiocarbamate series (Tennam, ferbam) and the closely related thiram acted quite differently. Not only did they not render the plant more susceptible, but actually they provided a marked degree of control of gray mold.

The apparent degree of control shown by captan (Table 2 and Fig. 1) might more accurately reflect the absence of zineb in the spray program during the latter part of the season.

In the light of these results a different interpretation of Darby's[6] work is possible. In Tables 1 and 2 of his report, it is shown that plots sprayed with any of the "bis" carbamates had a much higher disease incidence than the checks. For example, 75 percent of the plants in the zineb plots (Table 2, Darby's report) showed infection; whereas none occurred in the check. Neither was sporulation found in plots sprayed with zineb plus dichlone. Following this speculative line it is suggested that, rather than true control with dichlone, what Darby may have demonstrated was increase of gray mold incidence through the use of the ethlenebisdithiocarbamates. Moreover, this increased incidence was counteracted through the concurrent use of dichlone (at least when in mixture with zineb). This hypothesis is further supported by the fact that where Darby used dichlone and zineb intermittently, incidence of the disease was intermediate. Darby's theory that gray leaf spot severity, through its effect on plant density, influences subsequent gray mold development has merit. But an analysis of his data in his Tables 2 and 3 suggests that other factors must also be involved. For example, plant density in "no-fungicides" plots was 3.12, and in the "zineb-PCNB alternate" plots, 3.81. This difference in plant density would not appear to be great enough to account for the differences in gray mold incidence (43 percent) shown in Table 2 of his report. In our own work, disease incidence in plots sprayed with a nabam-zinc sulfate plus dichlone-mixture was quite similar to that in the check, but significantly higher than where dichlone was used alone (Table 3), and significantly less than in plots sprayed with nabam (plus metal salts). This further suggests the counteractive effect of dichlone.

Footnotes for Table 3, page 724.

[a] Active ingredients and percentage composition of materials listed as follows: Dithane D-14, 19% nabam; tribasic copper sulfate, 53% metallic copper; Orthocide 50-W, 50% captan; Griseofulvin, unknown composition; Terraclor, 75% pentachloronitrobenzene; Merck Fungicide, unknown composition; Agristrep, 15% streptomycin sulfate, Manzate, 70% maneb; Phygon, 50% dichlone; Tennam, aqueous suspension of manganous dithiocarbamate; Vancide 51, sodium salts of dithiocarbamic acid and 2-mercaptobenzothiazole.

[b] See text for explanation of scores.

[c] Scored 2 days after 13th application. 0 = no injury; 5 = severe injury.

[d] Number of rotted fruit per 100 lbs. ungraded fruit. Rots primarily due to Botrytis cinerea and Rhizoctonia solani.

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[6] See footnote 3

Several possible explanations can be offered to account for the apparent phenomenon of a fungicide increasing disease incidence:

a) Weakening of the plant from phytotoxicity.
b) A buildup of hygroscopic material such as sodium sulfate creating moisture conditions more favorable to spore germination and growth of the fungus.
c) Some other possible relationship with or effect on the fungus.
d) A vital relationship between the fungicide or some degradation product and the host plant, which, in turn, affects host-parasite relationship.

Although cases could be built for or against any of these hypotheses not enough evidence is at hand at the present time to credit or discredit any one of them completely.

On the basis of all available data, it would appear that this increased disease incidence is the result of many (15 to 20) applications. Where Darby used zineb, nabam, maneb, and dichlone in an alternating program, with relatively few applications of each, disease incidence was intermediate. This was also so in our own work where maneb was used only during the latter part of the season (8 applications).

To summarize -- on the basis of the information presented here plus the fact that the emergence of Botrytis gray mold as a major disease problem in certain areas of south Florida closely parallels the adoption of the ethylenebisdithiocarbamate fungicides in the spray program, the hypothesis that these materials are instrumental in producing this phenomenon appears to have considerable merit.

Could a similar phenomenon explain the sudden "flareup" of other minor diseases of other crops? As in the case of gray mold of tomato, many of these increases in importance have been coincident with the use of the new organic fungicides.

Finally, looking to the bright side of the picture, if it could be assumed that the increased disease incidence reported here is the result of chemically induced susceptibility, might it not be possible on the other hand that certain chemical-host plant interactions would result in induced disease resistance?

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FUNGICIDE AND INSECTICIDE SEED TREATMENTS OF PEAS AND BEANS, 1953-55[1]

Donald J. deZeeuw, Gordon E. Guyer and Axel L. Andersen[2]

Abstract

Three years' testing of seed treatment fungicides, insecticides and combinations on Round Pod Kidney Wax beans at East Lansing, Michigan and on Alderman peas at East Lansing or Jackson, Michigan is reported. Seventy-six treatments, including commercial preparations at various rates and laboratory mixtures of fungicides and insecticides, were used in one or more of the trials. Most materials containing the fungicides captan, thiram, or dichlone were beneficial on both peas and beans. The mercury compounds generally gave less consistent protection. One experimental material, Ethyl B-856, was outstanding in pea trials and was as effective as the established captan and thiram fungicides. In spite of the apparent low incidence of seed-corn maggot in the experimental plots insecticides generally were of benefit to beans. Insecticides were usually slightly harmful to peas, whether used alone or in combination with fungicides. The differences in stands in favor of or against added insecticide were usually less than the difference required for statistical significance but were considered consistent enough to indicate biological significance.

MATERIALS AND METHODS

Round Pod Kidney Wax beans and Alderman peas[3], previously found suitable for damping-off experiments (1, 2, 5) were used in the trials reported here. Treatment materials were applied to the seeds as slurries or liquids except as noted. Sufficient quantities of the slurry materials were weighed to deliver the treatment rate for each seed lot and a minimum quantity of water was added to facilitate spreading and sticking to the seed. The amount of water used was determined by trial and in most cases was approximately 0.5 percent of the seed weight.

New, experimental, or coded materials together with their manufacturers and compositions are listed in Table 1. Other materials have been reported elsewhere (1, 2, 3, 6).

The experimental plots consisted of single rows of 100 or more seeds replicated at least four times. All plots were randomized to allow for statistical evaluation of the numbers of healthy plants 3 to 5 weeks after planting. The plots were observed periodically for the presence of seed-infesting insects and evidence of damage by them.

EXPERIMENTAL RESULTS

1953: Peas were seeded late (May 9) and beans at the normal time for Michigan (May 26). Stand counts were made on June 3 and June 12, respectively (Table 2). Most of the accepted seed-treatment materials as well as some of the experimental treatments gave significant protection to both peas and beans. On beans, combination materials such as Seed Guard or I and D were superior to the fungicide Orthocide 75 or Arasan SF-X alone. The differences were not sufficient for statistical significance in this experiment. On peas, the converse was true. In this case the combination materials were slightly less effective than the fungicides alone.

The ten best materials in order of decreasing effectiveness were: for peas -- Orthocide 75, Semesan, Phygon Seed Protectant, Seed Guard, L-640, Arasan, Fermuline, Vancide 51, L-224, and Merculine; for beans -- Merculine, Seed Guard, Fermuline, Semesan, I and D, Orthocide 75, Setrete, C-13-1212, Agrox, and Vancide 51.

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3 Seeds furnished gratis by the Ferry-Morse Seed Company for much of this work.

Table 1. Name, manufacturer, and chemical composition of certain seed treatment materials used in 1953-55 trials on peas and beans.

Name or Code	Manufacturer	Composition
Cuprosal	H. L. Woudhuysen	20% emulgate of copper salicylate
Panogen 42	Panogen Inc.	6.3% Methyl mercury dicyandiamide
Ethyl B-856	Ethyl Corp. (Pittsburg Coke)	75% 1, 3-dichloro-5, 5-diphenyl hydantoin.
Ethyl B-622		50% 2, 4-dichloro-6--(o-chloroanilino)-s-triazine
Vancide F-995	Vanderbilt Chem. (Niagara	75% Mn salt of Vancide 51
Vancide F-407	Chem. Div. Food Machinery Corp.)	30% Ca salt of dimethyldithiocarbamic acid.
Vancide 51-ZW		75% Zn salt of Vancide 51
Vancide F-1056		75% mixture of Zn, Mn, Cu, and Fe salts of Vancide 51
Vancide F-845		100% ethyl dibromomalonate
Vancide Cumate		copper dimethyl dithoicarbamate
Cunilate (2472)	Scientific Oil Compounding Co.	10% emulsion of copper-8-quinolinolate
Cunimeme (2528)		33.5% emulsion of Zn dihydro abietyl amino 2-ethylhexoate plus 8-ZN oxy-1-benzazinium 2-ethyl hexoate.
Natriphene	Natriphene Co.	Not known.
Puraseed (C13-1212)	Gallowhur Chemical Corp.	6.25% each phenyl amino Cd dilactate and phenyl Hg formamide
Tennam-10	Tennessee Corp.	90% manganous dithio carbamate
Merbam-10	Chipman Chem. Co.	10% phenyl Hg dimethylamino thiono methyl mercaptan.
Panogen A	Panogen Inc.	25% thiram, 50% aldrin
Panogen B		60% thiram, 15% aldrin
Panogen C		75% thiram
Panoram D-31		56.2% thiram, 18.8% dieldrin equivalent
Panogen PA-2N		0.4% methyl Hg dicyandiamide, 28.5% aldrin.
Ceresan D	E.I. duPont deNemours &Co., Inc.	2.1% Hg equivalent in alkyl mercury product
Ceresan S		6.2% Hg equivalent in alkyl mercury product

1954: In 1954 peas were planted late (May 15) and the beans were planted early (May 17) for East Lansing. The trials included 22 treatments tested in 1953 and 17 additional treatments (Table 3). As in 1953, the combination materials such as I and D, Seed Guard, etc., proved at least slightly superior to the fungicide component on beans but inferior on peas. Seven of the 17 new materials (Ethyl B-856, Mema, Orthocide and dieldrin, thiram and dieldrin, U.S.R. thiram, Vancide F-995, and Cuprosal) appeared promising for both peas and beans, and one, Ethyl B-856, was outstanding on peas.

The ten best materials for peas in this trial were Ethyl B-856, L-224, L-640, Arasan SF-X, Mema, Semesan, Orthocide 75, I and D, Fermuline, and Agrox. On beans, Orthocide and dieldrin, Seed Guard, I and D, Ethyl B-856, Thiram and dieldrin, Mema, Merculine, Semesan, Fermuline and Setrete were the superior materials.

1955: Fifty treatments, which included duplicate plantings of the pea trials at East Lansing and Jackson, were made in 1955[4]. Peas were planted early (April 7 and April 14) at both locations and suffered some frost damage in early May. Beans were planted on May 23. Stands were determined approximately 4 weeks after planting (Table 4). The second part of Table 4 contains the results obtained with combinations of the fungicides and insecticides mixed by the authors, whereas those in the first group were all compounded by the manufacturers. Equivalent amounts of fungicide were used in both fungicide and fungicide-insecticide treatments.

Most of the 1955 results obtained with combination treatments corroborate those of 1953 and 1954. In all cases the combination treatments on beans were slightly better than the fungicide alone. On peas at East Lansing, the fungicide treatments alone gave consistently better stands than the combinations. The exceptions to previous observations were noted in the Jackson plantings. At Jackson, two combinations, U.S.R. Phygon and lindane, and Panogen thiram and aldrin, were superior to the fungicides Phygon Seed Protectant and Panogen thiram. In several additional instances, other combinations, thiram-dieldrin 2-1, thiram-heptachlor 2-2, thiram-dieldrin 2-2, captan-dieldrin 2-1, and captan-dieldrin 2-2, mixed by the authors, were slightly superior to the corresponding fungicide component used alone.

The order of effectiveness for the commercially compounded materials on beans was Panoram D-31, Seed Guard, I and D, Delsan AD, Merbam-10, Phygon Seed Protectant and lindane, Orthocide and dieldrin, Orthocide 75, Panogen B, and Ethyl B-856; on peas at East Lansing, Ethyl B-856, Panogen C, Orthocide 75, Panogen B, Arasan SF-X, Ceresan S, Phygon Seed Protectant, Delsan AD, Phygon Seed Protectant and dieldrin, and Panogen A; and on peas at Jackson, Phygon Seed Protectant and lindane, Panogen B, Panogen C, Phygon Seed Protectant, Orthocide 75, Ceresan S, Merculine, Ethyl B-856, Arasan SF-X, and Panoram D-31.

CONCLUSIONS

Duplication of the various trials was not attempted each year but certain of the more effective or interesting materials were used for purposes of comparison. In this way, it was possible to compare the results obtained with certain fungicide and combination treatments for consistency over the 3 years period. Although some differences in stand between combination treatments and corresponding fungicide were less than the order required for statistical significance, they were sufficiently consistent to include them in the discussion. Certain of these differences in response to fungicide and fungicide-insecticide combinations on peas and beans were reported earlier (4). Without exception, the stands of beans were better with the combination treatment than with the corresponding fungicide treatment alone. With several exceptions, the stands of peas were poorer when seeds were treated with combinations of the fungicide and the insecticide than when they were treated with the fungicide alone. At Jackson, the peas were planted early in heavily manured sandy loam and the stands were counted later than at East Lansing. Although seed-corn maggot infestation was apparently slight in all of the experiments reported, there is presumptive evidence for their occurrence in the peas at Jackson and beans in other trials.

It is doubtful whether insecticides will be beneficial either alone or in combination with a fungicide for peas in Michigan. The findings indicate that the insecticide is at least slightly harmful and the harmful effects are often not entirely overcome by the protective action of the fungicide component in combination treatments.

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[4]Cooperation of Mr. Clare Rossman, Farm Superintendent of Southern Michigan State Prison, Jackson, Michigan.

Table 2. Stands of Alderman peas and Round Pod Kidney Wax beans from seed given various treatment, East Lansing, Michigan. 1953[a]

Material	Rate per 100 lb. of seed	Seeds producing healthy pea plants	Seeds producing healthy bean plants
	oz.	%	%
Orthocide 75	2	69.0	62.6
Seed Guard	2	60.3	68.0
Arasan SF-X	2	41.3	53.2
Arasan (dry)	2	53.5	50.2
I.and D	2	40.7	63.5
Semesan (dry)	2	62.8	64.3
Phygon Seed Protectant	2	60.6	54.0
Spergon (dry)	2	36.2	43.0
Merculine	2	52.5	68.5
Fermuline	2	53.2	64.7
Mercusol	2	24.5	38.0
C 13-1212 (dry)	2	50.8	59.8
C 15-1212 (dry)	2	40.3	52.0
C 12-2525 (dry)	2	49.7	46.4
Setrete	2	52.0	61.8
Vancide 51	6	53.0	55.8
L-224 (dry)	2	53.0	50.7
L-640 (dry)	2	57.2	----
Agrox (dry)	2	49.5	57.5
Panogen 15	2	27.2	45.7
Panogen 15	4	----	53.8
Panogen 5025 S	2	39.0	39.2
Panogen 5202 K (dry)	2	29.3	30.8
Tritisan	2	17.5	21.3
Brassicol	2	14.8	28.5
Mycon	2	16.8	25.4
Velsicol 48-CS-73	2	12.0	23.0
Velsicol 48-CS-36	2	17.3	25.5
Control	-	16.5	30.8
L. S. D.			
5 percent level		7.1	11.5
1 percent level		9.4	15.3

[a]Six replications of 100 seeds each. Peas planted May 9 and stand counts made June 3. Beans planted May 26 and stand counts made June 12.

Table 3. Stands of Alderman peas and Round Pod Kidney Wax beans from seeds given various treatment, East Lansing, Michigan 1954[a].

Material	Rate per 100 lb. of seed	Seeds producing healthy pea plants	Seeds producing healthy bean plants
	oz.	%	%
Orthocide 75	2	61.2	45.6
Seed Guard	2	58.1	59.9
Arasan SF-X	2	62.7	50.6
Arasan (dry)	2	53.1	39.9
I and D	2	60.6	58.6
Semesan (dry)	2	61.3	52.8
Phygon Seed Protectant	2	59.0	48.9
Spergon (dry)	2	37.5	28.6
Merculine	2	29.9	52.9
Fermuline	2	60.0	52.5
C 13-1212 (dry) (Puraseed)	2	59.5	47.8
C 15-1212 (dry)	2	45.6	39.9
C 12-2525 (dry)	2	54.5	40.6
Setrete	2	59.2	51.5
Vancide 51	6	49.0	46.8
L-224 (dry)	2	67.6	39.4
L-640 (dry)	2	65.1	47.0
Agrox (dry)	2	60.0	45.4
Panogen 15	2	55.4	38.0
Panogen 15	4	59.8	49.9
Panogen 5025 S	2	48.1	5.4
Panogen 5202 D (dry)	2	42.1	25.1
Mema	2	61.8	54.9
Cuprosal	2	54.1	40.3
Panogen 42	1	45.2	40.1
U.S.R. thiram (dry)	2	54.2	47.7
Orthocide and dieldrin	2	53.9	63.9
DuPont thiram and dieldrin	2	52.0	55.5
Ethyl B-856	2	69.6	57.2
Ethyl B-622	2	41.8	25.2
Vancide F-995	2	51.9	49.7
Vancide F-407	2	46.1	35.5
Vancide 41-ZW	2	45.5	42.8
Vancide F-1056	2	43.2	33.9
Vancide F-845	2	22.7	22.5
Vancide Cumate	2	33.7	32.7
Cunimene (2528)	2	43.5	35.6
Cunilate (2472)	2	36.5	30.5
Natriphene (dry)	2	34.1	22.7
Control		39.0	20.8
L. S. D. 5 percent level		7.5	17.6
1 percent level		10.0	23.3

[a]Five replications of 200 seeds each. Peas planted May 15 and stand counts made June 7. Beans planted May 17 and stand counts made June 11.

Table 4. Stands of Alderman peas and Round Pod Kidney Wax beans from seeds given various treatment. Peas grown at East Lansing and Jackson, and beans at East Lansing, Michigan. 1955[a].

Treatment Group and Material	Rate Per 100 lb. of seed	Seeds producing healthy pea plants		Seeds producing healthy bean plants
		East Lansing	Jackson	East Lansing
	oz.	%	%	%
Commercially Compounded materials:				
Orthocide 75 (captan 75 pct.)	2	83.5	78.0	63.2
Seed Guard	3	74.2	72.2	71.2
Arasan SF-X (thiram 75 pct.)	2	83.2	75.2	54.6
I and D	3	----	----	67.0
Semesan	2	----	----	50.8
Phygon Seed Protectant (dichlone 50 pct.)	2	81.0	81.5	53.2
Merculine	2	76.6	77.5	59.4
C 13-1212 (Puraseed)	2	----	----	56.5
Setrete	2	----	----	53.4
Vancide 51	6	----	----	40.2
Agrox (dry)	1	77.7	73.0	----
Panogen 15	2	----	----	50.4
Mema	1	69.2	74.5	45.4
Mema	2	----	----	54.2
Orthocide and dieldrin	3	----	----	64.0
DuPont thiram and dieldrin (Delsan AD)	3	80.0	74.5	66.2
Ethyl B-856	2	92.0	77.0	60.0
Vancide 51-ZW	2	----	----	50.0
Puraseed	3	----	----	47.2
Merculine	1	----	----	55.4
Panogen 15	1	63.5	60.7	41.2
U.S.R. Phygon and dieldrin	3	79.7	73.5	56.8
U.S.R. Phygon and lindane	3	69.2	85.7	64.8
Tennan-10	2	----	----	46.4
Merbam-10	2	77.0	69.0	66.2
Panogen A	3	79.5	72.0	31.6
Panogen B	3	83.5	84.5	61.0
Panogen C	3	84.5	83.7	58.0
Panoram D-31	3	77.2	74.7	76.6
Panogen PA-2N	1	60.2	74.5	29.2
Panogen PA-2N	2	----	----	47.8
Mergamma	1	64.7	69.5	----
Ceresan D	1	77.7	70.7	43.3
Ceresan D	2	----	----	52.6
Ceresan S	1	82.5	77.7	55.2
Ceresan S	2	----	----	34.2
SP-50 (dry)	2	50.7	66.5	----
Laboratory Compounded Materials: [b]				
dieldrin 50 pct.	1	43.7	47.5	----
heptachlor 25 pct.	2	39.5	46.7	----
dieldrin 50 pct.	2	40.7	55.2	----
thiram-dieldrin	2-1	77.7	78.7	----
thiram-heptachlor	2-2	77.0	82.2	----
thiram-dieldrin	2-2	76.2	83.0	----
captan-dieldrin	2-1	75.2	80.5	----
captan-heptachlor	2-2	71.2	76.0	----
captan-dieldrin	2-2	75.2	81.0	----
dichlone-dieldrin	2-1	77.2	76.7	----
dichlone-heptachlor	2-2	72.0	80.2	----
dichlone-dieldrin	2-2	69.0	76.7	----
control	---	51.5	52.7	23.4
L.S.D.				
5 percent level		10.0	9.3	11.8
1 percent level		13.4	13.2	15.6

[a] Peas: 4 replications of 100 seeds each. Planted April 7 at Jackson and stand counts made May 10, planted April 14 at East Lansing and stand counts made May 6.
Beans: 5 replications of 100 seeds each. Planted May 23 and stand counts made June 16.

[b] Fungicide components of the laboratory compounded materials Orthocide 75 % captan), Arasan SF-X (75 % thiram) and Phygon Seed Protectant (50 % dichlone).

Literature Cited

1. Andersen, Axel L., and Donald J. deZeeuw. 1952. Seed treatment studies for damping-off control in garden and canning beans. Michigan Agr. Expt. Sta. Quarterly Bul. 34: 357-364.
2. Andersen, Axel L., and Donald J. deZeeuw. 1952. Pea seed treatment investigations. Report of progress. Michigan Agr. Expt. Sta. Quarterly Bul. 35: 25-33.
3. deZeeuw, Donald J. 1954. Fungicide treatment of table beet and spinach seeds for the prevention of damping-off. Michigan Agr. Expt. Sta. Quarterly Bul. 37: 105-118.
4. deZeeuw, Donald J., Axel L. Andersen, and Gordon E. Guyer. 1955 Comparison of fungicide and fungicide-insecticide seed treatments of peas and beans. (Abstr.). Phytopathology 46: 10.
5. deZeeuw, Donald J., Axel L. Andersen, Leland G. Merrill, and William Zurakowski. 1954. Fungicide-insecticide combination seed treatment of beans for the control of damping-off and seed-corn maggot. Michigan Agr. Expt. Sta. Quarterly Bul. 37: 204-217.
6. Leukel, R. W. 1953. Cooperative tests of seed-treatment chemicals on spring wheat and oats in 1953. Plant Dis. Reptr. 37: 587-594.

MICHIGAN STATE UNIVERSITY AND UNITED STATES AGRICULTURAL RESEARCH SERVICE

EFFECT OF METHOD OF INOCULATION ON CONTROL OF HEAD SMUT OF MOUNTAIN BROME BY SEED TREATMENT[1]

Jack P. Meiners[2]

One of the problems encountered in the testing of fungicides for smut control is the development of a method of inoculation that will give uniformly high smut infection while simulating as closely as possible natural infestations of the seed. The use of naturally infested seed may result in a degree of infection too low to adequately test experimental fungicides, while inoculation by artificial means, e.g. the partial vacuum method, may sometimes result in the failure of otherwise effective seed treatments (2).

In the case of head smut (Ustilago bullata Berk.) of mountain brome, seed-treatment studies have been conducted using seed inoculated by the partial vacuum method (4, 5). This has resulted in extremely high smut infection which has been controlled only by fungicides that are considered to be volatile. Therefore, the question arose as to whether smut in seed inoculated by this method is as easily controlled by seed-treatment materials as it is in seed infested under natural conditions. It was suggested that treatment of evacuated seed may result in otherwise effective fungicides proving ineffective. To ascertain whether this can be the case, seed treatment tests were conducted to determine the effect of methods of inoculation upon the degree of head-smut control.

The first test compared seed inoculated by the partial vacuum method with seed that had been dusted with dry spores. Following inoculation the seed lots were treated with Arasan, a non-volatile fungicide, and with Ceresan M, a volatile material. Results of these tests showed that treatment with both fungicides eliminated the smut in seed inoculated with dry spores. Ceresan M eliminated the smut in the evacuated seed but Arasan allowed 5.3 percent infection. Plants from untreated seed inoculated by either method were nearly 100 percent smutted. These preliminary results showed, therefore, that the dry application of smut spores to the seed resulted in uniformly high infection, and that the smut could be controlled by applications of non-volatile fungicides. However, whether seed inoculated by this method is comparable to naturally infested seed with regard to smut control by non-volatile seed treatment materials could be determined only by using naturally infested seed.

To secure such seed for seed treatment tests, non-smutted seed was planted in alternate rows with smutted seed so that each smut-free row grew between rows that were nearly 100 percent smutted. Seed from the smut-free rows was then harvested and threshed and was used as the naturally infested seed. A portion of the naturally infested seed was also inoculated under partial vacuum in a heavy suspension of spores. This lot was designated as the evacuated seed. These lots were treated with several fungicides, including both volatile (Ceresan M) and non-volatile (Agrox, Arasan, Arason SF-X) materials. Methods of treating were similar to those used previously with head smut (4, 5). Following treatment, the seed was allowed to stand in closed paper bags for one week and then planted in plant bands in the greenhouse. The seedlings were later removed to the cold frames for vernalization and finally transplanted to the field. The results are summarized in Table 1.

Smut in the untreated check rows of both naturally infested and evacuated seed averaged over 98 percent in each case. However, great differences were noted in the ability of fungicides to control smut induced by different methods of inoculation. Both volatile and non-volatile fungicides controlled the smut in seed naturally infested, whereas only Ceresan M, the volatile seed treatment, controlled the disease in the seed inoculated by partial vacuum. This was true regardless of whether the fungicides were applied as dusts or slurries.

Leukel (2) found that oat seed inoculated by the partial vacuum method occasionally resulted in the failure of certain fungicides to prevent infection, whereas control was obtained with these same materials when the seed had been inoculated with dry spores. He found upon examining the seed that the evacuation method resulted in a heavy spore load beneath the glumes, particularly near the embryo. With the dry method, no spores are placed beneath the glumes. To determine if a similar situation exists in the case of mountain brome seed inoculated by partial vacuum and natural means, a large number of seeds inoculated by each method were examined for presence of spores.

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[1] Scientific Paper No. 1504, Washington Agricultural Experiment Stations, Pullman.

[2] Formerly Associate Pathologist, Washington Agricultural Experiment Stations, Pullman, and Collaborator, Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

Table 1. Effect of method of inoculation on control of head smut of mountain brome by seed treatment materials.

Treatment	Oz. per bu.	Percent head smut[a] from seed inoculated by	
		Natural infestation	Partial vacuum
Untreated		98.5	98.3
Slurry			
Arasan SF-X	4	0.0	90.3
Ceresan M	1	0.0	0.7
Agrox	1	0.6	81.7
Dusts			
Arasan	4	0.0	48.8
Ceresan M	1	0.2	0.0
Agrox	1	0.0	13.2

[a] Average of three replications. Smut percentages based on total head counts per row.

Seed inoculated by partial vacuum had large numbers of spores on and under both palea and lemma, particularly in the area of the embryo. Seed exposed to natural infestation also had numerous spores on the outside of the glumes and underneath the glumes where the palea and lemma did not adhere to the caryopsis. However, in contrast to evacuated seed very few spores were found beneath the glumes adjacent to the embryo. With both types of inoculation, the glumes were equally tightly appressed to the caryopsis. Whether the presence of a heavy spore load in the vicinity of the embryo may account for the differential ability of fungicides to control the smut is not known. However, the results have definitely shown in the case of mountain brome grass, as in the case of oat smut (2), that efficient treatment materials may be eliminated from favorable consideration by the partial vacuum method of inoculation and that fungicide testing must be done with naturally infested seed or seed inoculated by methods that give similar results.

On the basis of information obtained from initial seed-treatment experiments to control head smut in grasses, Arasan was recommended as a seed treatment for the control of this disease (1). Results of subsequent experiments using Bromar mountain brome heavily inoculated by the partial vacuum method with a particularly virulent race of head smut (3) indicated that Arasan and other non-volatile fungicides did not give adequate control (4, 5). Results reported herein, using naturally infested seed of Bromar, tend to confirm the earlier recommendations. Therefore, it appears that Arasan and Arasan SF-X can again be recommended along with the volatile mercury compounds Ceresan M and Panogen (4, 5) for control of head smut in mountain brome. As was pointed out previously (1), Arasan has the added advantage over mercury seed treatments in that it may be applied at heavy dosages without danger of injury to the seed, and thus would be more practical and convenient for application to small lots of seed where the weighing of small amounts of fungicide is tedious.

The non-volatile mercury, Agrox, also controls head smut under conditions of natural infestation, and therefore can be recommended for head smut control in mountain brome.

Literature Cited

1. Fischer, G. W., and J. P. Meiners. 1952. Comparative value of several fungicides in the control of head and stripe smuts in certain forage grasses. Washington Agr. Exp. Sta. Bul. 523. 18 pp.
2. Leukel, R. W. 1937. Seed treatment experiments with oats naturally and artifically inoculated with smuts. U. S. Dept. Agr. Tech. Bull. 568. 16 pp.

3. Meiners, Jack P. 1952. A new race of head smut on Bromar variety of mountain brome. Plant Dis. Reptr. 36: 166.
4. _____ 1953. Seed treatment for control of head smut in mountain brome in 1952. Plant Dis. Reptr. 37: 152-153.
5. _____ and Sherl M. Dietz. 1953. Seed treatment trials for control of head smut in mountain brome in 1953. Plant Dis. Reptr. 37: 595-596.

WASHINGTON AGRICULTURAL EXPERIMENT STATIONS, PULLMAN, AND THE FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE.

STUDIES ON SORGHUM HEAD SMUT

R. W. Leukel

The increasing incidence of sorghum head smut (Sphacelotheca reiliana (Kuehn) Clint.) in the Mid-west sorghum-growing areas makes it seem desirable and timely to mention certain facts about this disease that may not be generally known. Some of these facts were learned through studies made by several workers many years ago. Other details concerning the disease have been learned through more recent studies.

Potter (3) in 1914 reported that head smut is wind-distributed throughout the locality where it occurs, and that infection in plants is caused by soil-infesting spores.

Christensen (1) found that the optimum temperature for infection is 28°C, the minimum temperature 16°C in very wet soil and below 12°C in very dry soil, while the maximum temperature is 36°C.

Reed et al. (4) reported that certain selections of feterita, milo and broomcorn seemed to be immune from head-smut, kafirs and kaoliangs were resistant, while the sorgos, in general, were highly susceptible. Head-smut from corn did not attack sorghum appreciably, and head-smut from sorghum was not virulent on corn. Pronounced indications of infection were not evident until heading time. Frequently the main head was normal, while the branch heads were infected.

In several of the systemic cereal smuts, infection of the host plants supposedly takes place before the seedlings emerge from the soil. This did not seem to hold true for sorghum head smut when plants were transplanted from infested soil in the greenhouse to infested and non-infested soil outdoors. The plants that were transplanted to the infested soil developed 54.5 percent infection, while those transferred to non-infested soil showed only 24 percent infection. The logical conclusion is that some of the plants became infected after they had been transplanted to the infested outdoor soil.

Surface-sterilized seed of Cody sorghum was planted in sterilized soil. Four days after emergence the seedlings were transplanted to steamed soil that had been artificially infested with spores of head-smut. A temperature of 28°C was maintained for several days after transplanting. When all of the plants had headed 60 percent were found to be infected, showing clearly that post-emergence infection had occurred. In two separate concurrent tests in which surface-sterilized seed was planted directly in this same smut-infested soil, one lot of plants developed 67 percent infection and the other 50 percent, while no infection occurred in steamed soil.

An experiment was then designed to determine, if possible, how old a plant must be to escape infection if transplanted to infested soil.

Weekly plantings of clean, surface-disinfected seed of Cody sorghum were made in steamed-soil in 5-inch pots from May 26 to July 15. In the meantime the soil in the greenhouse benches was mixed with a generous quantity of head-smut spores and kept moist for 9 weeks.

On August 1, 1955 80 plants from each of the eight plantings were transplanted to this infested soil. At that time the plants in the first planting were over 9 weeks old, each had 8 visible leaves, and the growing point was 3 centimeters above the crown. Dissection showed 8 nodes formed or forming between the crown and the growing point[1]. The plants in the final planting were less than 2 weeks old and were in the 2-leaf stage. The plants were transplanted to the infested soil in the greenhouse bench in rows 6 inches apart with 8 plants per row. The number of plants per date-of-planting ranged from 64 to 80. As the plants headed a record was kept of the healthy and smutted plants in each group. The smutted plants were removed and the smut-free plants were cut back to within 6 inches of the soil surface so that another crop of heads could develop. Many of the heads that developed in the cut-back plants proved to be smutted. The smut-free heads were cut back again and a third crop of heads was grown. Final data on the percentage of plants smutted in the third crop were taken March 2, 1956. The results, presented in Table 1, show that head smut can invade sorghum plants several weeks old. It is possible that infection may be induced in second-growth plants by applying viable spores to the cut surface of the stubble as in the case of Johnson grass smut (2). This possibility is being investigated.

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[1]The writer is indebted to Dr. H. A. Borthwick for these observations.

Table 1. Infection by head smut in plants of Cody sorghum 2 weeks to 9 weeks old transplanted from non-infested soil to soil infested with head smut, Plant Industry Station, Beltsville, Maryland, 1956.

Date planted	Age of transplants (days)	Total plants	Percent of plants infected on Oct. 10, '55	March 7, '56	April 10, '56
5/24	66	72	4.2	73.9	84.1
6/3	56	80	7.5	62.9	73.3
6/10	49	64	6.3	80.0	86.0
6/17	42	63	23.8	51.9	68.5
6/24	36	64	20.3	50.0	56.0
7/1	29	64	28.1	58.4	59.4
7/8	22	64	31.3	57.6	60.3
7/15	15	64	50.0	79.4	82.0
7/29	-	60	65.0	70	75.0

Literature Cited

1. Christensen, J. J. 1926. The relation of soil temperature and soil moisture to the development of head smut in sorghum. Phytopathology 16: 353-357.
2. Leukel, R. W. and Martin, John H. 1950. Loose kernel smut of Johnson-grass. Phytopathology 40: 1061-1070.
3. Potter, Alden A. 1914. Head smut of sorghum and maize. Jour. Agr. Res. 2: 339-381.
4. Reed, George M., Marjorie Swabey, and Laura Alma Kolk. 1927. Experimental studies on head smut of corn and sorghum. Bull. Torrey Bot. Club. 54: 295-310.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, PLANT INDUSTRY STATION, BELTSVILLE, MARYLAND

THE PROPAGATION OF ROOT-ROT-FREE STRAWBERRY AND TRAILING CANE FRUIT PLANTS [1]

M. C. J. van Adrichem and J. E. Bosher

Abstract

The method described was designed primarily to provide disease-free plants of strawberries and trailing cane fruits for studies on effects of soil fumigation and on parasitism by organisms causing root rot. It is also a practicable method for growers to establish root-rot-free foundation plantings.

Recent investigations at the Plant Pathology Laboratory at Saanichton, British Colombia (1, 2, 3), show that root-rot fungi and root-lesion nematodes are important causes of decline in strawberries and loganberries. Red stele (Phytophthora fragariae) is present in many strawberry fields. Cane and crown gall (Agrobacterium rubi and A. tumefaciens) are of major importance in some cane fruit plantations (3). Both Bosher (1) and McKeen (3) have pointed out the probability of spreading the diseases into new plantations by the use of diseased plants. Their studies on the control of root-rot complexes by soil fumigation showed the importance of having plants absolutely free from root rot. Because of the greater rate of spread of root-rot organisms in fumigated than in normal soil, their presence in trace amounts on the planting stock often nullifies the effects of soil fumigation. Vaughan (5) recently described a method of maintaining a nucleus stock of red-stele-free strawberry palnts.

The following method has been developed in order to secure root-rot-free planting stock for soil fumigation tests and for the study of Phytophthora fragariae and Verticillium sp., and to provide a method for growers and nursery men to obtain root-rot-free plants.

FIGURE 1. Comparative root growth of strawberry runners. Plant on left rooted in soil in field adjacent to mother plant. Plant on right rooted in punnet.

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[1] Contribution No. 1552 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

STRAWBERRIES

Fruitbaskets (punnets), size 8 x 8 x 4 inches, are filled with a 2:1 mixture of clean sand and peat and placed between the rows of strawberry plants in the field. Strawberry runners, as soon as they reach the baskets, are pegged down with wire hairpins to prevent movement by wind or other agency. One runner plant is rooted in each basket. As soon as two plants are rooted from each stolon they are severed from the parent plant. This is of vital importance if the parent plants are infected with Verticillium wilt, for, as stated by McKeen and Bosher (4), the young runner plants can collapse from Verticillium wilt. Shortly after the plants are rooted, the punnets are collected from the field and placed close together upon sheets of tarpaper for convenience of watering and other care. Because of the dry summers on Vancouver Island, the punnets must be watered at short intervals to permit adequate rooting. Fertilizer is added to maintain optimum growth.

As plants produced by this method form a heavy root system by the middle of August, satisfactory fall planting (Fig. 1) is assured. Foundation plots of these plants have been established on soil areas that have been fumigated with a nematicide or fungicide or both. At Saanichton, good results have been obtained with Dowfume M.C.2 at the rate of 2 pounds per 100 square feet under plastic cover. However, as M.C.2 does not adequately control Verticillium sp. (4), soils infested with this fungus can be more successfully treated with chloropicrin at the rate of 2-2.5 ml. per square foot (6). Normal precautions regarding tillage and moisture are essential for satisfactory soil fumigation. In addition, since strawberries appear to be very susceptible to injury by traces of the fumigant remaining in the soil, fumigation should be completed approximately 2 weeks before planting. The plots are then treated as foundation plantings, and runners for transplanting the following season are allowed to root freely.

TRAILING CANE FRUITS

Loganberries and other trailing cane fruit plants are usually obtained as rooted tips in commercial plantings, many of which are seriously infected with cane and crown gall and root-rot diseases (1, 2, 3). As a consequence, the new plants may be infected and diseases may be spread to new locations. To avoid this spread of diseases, the following practice has been adopted.

As soon as the primo canes are ready to tip, which, on Vancouver Island, is towards the end of September, 2-foot squares of tarpaper are laid beside the parent plants. Punnets filled with a 2:1 mixture of clean sand and peat are placed upon them and the cane tips are buried vertically therein. The tips are normally well rooted in early December at which time they are severed from the parent cane to avoid transmission of the cane and crown gall bacteria. The plants in the punnets are then taken from the field and placed upon tarpaper sheets to await spring planting or are planted directly in their permanent field position. The fall weather conditions on Vancouver Island are such that watering of the punnets is seldom required.

Literature Cited:

1. Bosher, J. E 1954. Root-lesion nematodes associated with root decline of small fruits and other crops in British Columbia. Canadian Jour. Agr. Sci. 34: 429-431.
2. McKeen, W. E. 1953. Loganberry decline on Vancouver Island. Plant Dis. Reptr. 37: 365-366.
3. McKeen, W. E. 1954. A study of cane and crown galls on Vancouver Island and a comparison of the causal organisms. Phytopathology 44: 651-655.
4. McKeen, W. E. and Bosher, J. E. 1955. Verticillium wilt in strawberries in British Columbia. Plant Dis. Reptr. 39: 371-372.
5. Vaughan, E. K. 1956. A method for eliminating red-stele fungus from valuable strawberry stocks. Phytopathology. 46: 235-236.
6. Wilhelm, S. 1953. Soil fumigation against Verticillium albo-atrum. Phytopathology 43: 593-596.

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PHYSIOLOGIC SPECIALIZATION IN COLLETOTRICHUM LAGENARIUM

Monroe J. Goode[1]

A severe anthracnose disease was observed on anthracnose-resistant watermelon varieties at four locations in Eastern North Carolina in 1954 and 1955. Disease symptoms were noted in the field on leaves, stems, and fruits of the Charleston Gray and Congo varieties. Inasmuch as these varieties were considered to be resistant, a study was initiated to determine the identity of the organism and the effects of artificial inoculation on resistant and susceptible watermelon varieties.

Isolations from diseased plant parts yielded a fungus which was indistinguishable culturally and morphologically from Colletotrichum lagenarium (Pass.) Ell. & Hals. Single spore cultures from isolates obtained from Congo and Charleston Gray fruits were used in inoculation tests. The anthracnose resistant varieties Charleston Gray (seed from 7 sources), Congo (seed from 5 sources), and Fairfax (seed from 4 sources), as well as the susceptible variety New Hampshire Midget, were used. Plants of various sizes, ranging from those in the cotyledonary stage to others with 1 to 12 true leaves, were included in these studies. Comparable inoculations were also made with a C. lagenarium isolate, N. C.-1, which is non-pathogenic to the three resistant varieties named. This isolate is representative of isolates usually obtained from susceptible varieties in North Carolina.

Watermelon plants of all the varieties from all the seed lots tested, irrespective of size at the time of inoculation, were susceptible to the isolates from Charleston Gray and Congo. Plants of the Fairfax, Charleston Gray, and Congo varieties were resistant, and New Hampshire Midget was susceptible, to the N. C.-1 isolate. The reaction of the Charleston Gray variety to these two isolates is shown in Figure 1. An additional isolate obtained in April, 1955, from C. F. Andrus, United States Department of Agriculture, Southeastern Vegetable Breeding Laboratory, Charleston, South Carolina, also proved pathogenic to these four varieties of watermelon.

The results of these tests suggest that there are two or more physiologic races of C. lagenarium. Further studies on this problem are in progress.

FIGURE 1. Charleston Gray watermelon seedlings inoculated with two different isolates of Colletotrichum lagenarium. Left: reaction to common isolate. Right: reaction of plants inoculated with Congo isolate.

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PINK RIB OF HEAD LETTUCE[1]

Robert B. Marlatt and Joseph K. Stewart[2]

Summary

An abnormality of head lettuce which consisted of a diffuse pink discoloration of the main leaf ribs and occasionally the smaller veins was found in the field in Arizona. The color was due to bright red areas in or on the walls of affected parenchymatous cells. It was demonstrated that this discoloration could also develop in storage but that low storage temperatures (37°F) delayed the appearance of severe symptoms. Severity of pink rib did not appear to be related to the amount of decay developing in storage.

During the last three years (1953-55) lettuce growers in Arizona have complained of a discoloration of lettuce heads which sometimes marred the appearance of their produce.

Symptoms

The main ribs (veins) at the bases of the leaves on a nearly mature head assume a faint pink color which may become intensified with time. The disease is found in the field on lettuce which appears to be normal in all other respects.

The pink coloration, when viewed macroscopically, appears diffuse and is more evident on the adaxial side of the leaf. Most commonly, the color extends only from the point of leaf attachment to that area where the main rib branches into several veins. In severe cases, veins that extend to the leaf margin also may be affected.

When an unbruised leaf rib is sectioned near its base, the more intensely colored tissue lies under the adaxial epidermis and is adjacent to the rib lacuna. The coloration is also frequently associated with bruised areas.

Free-hand sections of the main rib of a leaf were made near its base. In unstained mounts, these sections showed a bright red or amber discoloration of parts of the walls of scattered parenchymatous cells. Affected cells occurred singly or in groups of two or more. Frequently, adjoining walls of two cells were discolored. Colored matter within the cell lumen was occasionally found. This was more often reddish-amber than bright red.

The color remained in tissues stored in tertiary-butyl-alcohol, ethyl alcohol, acetic acid, formalin or xylol; however, the red gradually changed to amber. Tissue that was mounted in Canada balsom also retained its color and gradually became amber or yellow.

Free-hand sections of lettuce with pink rib were compared with sections from a variety of red lettuce, which normally contains a red pigment. The red lettuce contained a very few parenchymatous cells with walls showing red areas, but the greatest amount of reddish color was due to what is probably anthocyanin within the protoplasm. Upon freezing and thawing, the anthocyanin color disappeared from the red lettuce, but the wall discoloration remained in lettuce affected with pink rib. In fact, the pink rib color is intensified by freezing and thawing.

Storage

It was important to know whether pink rib would appear in lettuce during storage and whether or not lettuce affected with pink rib was more subject to decay than normal lettuce.

Decay in Storage -- During the course of a storage experiment, an entire lot of 80, apparently normal, trimmed lettuce heads gradually developed symptoms of pink rib. All heads showed symptoms after 25 days in storage. Half of the lot was kept at 37° and the rest at 47°F. Some heads were consistently more severely affected with pink rib throughout the storage period; others showed comparatively little discoloration. These were recorded as having severe

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[1]Arizona Agricultural Experiment Station Technical Paper No. 388.

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and slight damage, respectively.

The amounts of bacterial and fungous decay occurring after 25 days in storage were recorded for the severely and slightly affected heads. The amount of decay in a head was graded as: 0, none; 2, slight; 3, moderate; and 4, severe. Treatments were replicated 4 times; an analysis of results showed that there were no significant differences in amounts of bacterial or fungous decay between the severely and slightly affected heads.

Temperature Effects -- During the same experiment, 80 heads of trimmed lettuce were examined for pink rib shortly after being harvested and again after storage periods of 6, 13, 20 and 25 days. Lettuce was stored in paper cartons, 10 heads per carton. Four cartons were placed in a room kept at 37° and the remaining 4 were stored at 47°F. None of the heads had pink rib when first examined, but after 6 days in storage the disorder had appeared and became progressively worse during the remainder of the storage period. Differences in severity of pink rib were obvious only during the sixth day in storage. After that time the disease was so severe that differences due to temperature variance were difficult to discern. Pink rib was rated as: 0, none; 1, trace; 2, light; 3, medium; and 4, severe. After six days each of the 80 heads was rated for pink rib. Those stored at 47° averaged 0.575 while those stored at 37°F averaged 0.025. The LSD 1 percent was 0.325. Pink rib symptoms were significantly more severe in lettuce stored at 47° than in the lot held at 37° F.

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OBSERVATIONS AND SPECULATIONS ON RUST (PUCCINIA HELIANTHI SCHW.) AND SOME OTHER DISEASES OF SUNFLOWERS IN CHILE[1]

W. E. Sackston[2]

Summary

Sunflower rust was positively identified for the first time in Chile in 1954, at a number of locations extending from 90 to 850 kilometers south of Santiago. It is possible that the rust was introduced into Chile for the first time in 1954, or that it spread from some native wild host to sunflower. The evidence seems to indicate, however, that it was introduced into Chile appreciably earlier, possibly at about the same time as into Peru and Argentina, and escaped detection because less favorable environmental conditions prevented it from developing to the extent that it did in those countries.

Sclerotinia minor Jagger and Oidium sp. (presumably Erysiphe cichoracearum DC.) were also found on sunflowers in Chile for the first time in 1954.

Introduction

At the request of the Chilean government, the writer spent three months in 1954 studying sunflower diseases in Chile. The work was financed by Departamento Tecnico Interamericano de Cooperacion Agricola, Santiago, a co-operative agency of the Chilean and United States governments, functioning as a department of the Ministry of Agriculture of Chile.

Rust (Puccinia helianthi Schw.) is an extremely important disease of sunflowers (Helianthus annuus L.) in many countries. Although it was found in Peru in 1950 and in Argentina in 1952, and rapidly became destructive in both countries, the disease was not known to occur in Chile (7, 3).

The main objectives of the study, therefore, were to determine if rust was present in Chile, to determine its distribution, to estimate its probable importance, and to advise on measures to be taken to combat it. This paper, which presents some of the results of three months' work, is based largely on reports which were submitted to the sponsoring agencies at the conclusion of the assignment in May, 1954[3].

Observations

Observations were made in several short surveys near Santiago, and in the main survey, which covered most of the agricultural area from Santiago 1200 kilometers south to the end of the road system at Puerto Montt[4].

Sunflower rust was found for the first time in Chile on March 12, 1954, near Rancagua, about 90 kilometers south of Santiago. Only a few pustules were found on a total of five plants, which were approaching maturity. Rust was located also in six widely separated fields of 61 examined during the main survey, as follows:

East of Talca, 260 km. south of Santiago, one pustule in a field, sunflowers ready to harvest.

Longaví, 335 km. south of Santiago, telia on a few plants in a group, numerous uredia on a few plants near the other end of the field, sunflowers near maturity.

East of Chillan, 420 km. south of Santiago, a few telia on three plants, a few uredia on three other plants, sunflowers in field being harvested.

La Quiriquina, 455 km. south of Santiago, one pustule on one leaf of each of four plants, most sunflowers in the area already harvested.

East of Loncoche, 850 km. south of Santiago, one uredial pustule only, in a garden plot of about 50 plants, sunflowers in bloom.

Ancahual, 850 km. south of Santiago, one uredial pustule only, in a garden plot of

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1 Contribution No. 1550 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

2 Plant Pathologist, Plant Pathology Laboratory, Winnipeg, Manitoba.

3 Sackston, W. E. 1954. Summary report covering work under DTICA auspices. Unpublished.

4 Sackston, W. E. 1954. Report on sunflower disease survey from Santiago to Puerto Montt, Chile, in March, 1954. Unpublished.

about 50 plants, some plants in bloom, others mature.

Immediately after the first discovery of sunflower rust was reported to the Ministry of Agriculture, several teams of agronomists under the direction of Señora Dora Volosky de Hernandez were sent to make an intensive search of neighboring districts. These teams found rust in six additional fields, all with very light infections, within 250 kilometers of the first location.

Jerusalem artichoke or "topinambour" (Helianthus tuberosus L.) was examined in 11 plantings between Talca and Puerto Montt, but no rust was found on it.

A wild plant closely resembling Helianthus, later identified as Flourensia corymbosa DC., by Señor Carlos Muñoz P., Ministry of Agriculture, Santiago, was found in the lower reaches of the Andes mountains east of Talca. Clumps of the plants were heavily rusted in three of five locations. The rust, a species of Puccinia differing in appearance from P. helianthi, had not previously been reported on this host (5). Seedlings of F. corymbosa were immune from all of the isolates of sunflower rust with which they were inoculated in greenhouse experiments at Winnipeg.

Some diseases other than rust were noticed in the sunflower fields examined. Root rot and wilt, attributed to infection by Sclerotinia sclerotiorum (Lib.) Mass., were present in about half of the fields. In most cases, from less than 1 percent up to 10 percent of the plants were affected, with 50 percent of the plants attacked in one field. About 10 percent of the plants in a field of H. tuberosus near Orsorno were killed by Sclerotinia root rot. The sclerotia adhering to the roots and present in the pith of the affected plants in most fields were only 1 to 2 mm in length; in a few fields, including the one of Jerusalem artichoke, the sclerotia were from 3 to 20 mm long, and appeared identical with those formed by S. sclerotiorum on sunflowers in Manitoba. Laboratory studies showed that the two forms were distinct in culture. The small form was later identified as S. minor Jagger by Constance A. Bowerman, Botany and Plant Pathology Division, Canada Department of Agriculture, Ottawa. This fungus, not previously recorded on sunflowers in Chile, proved even more pathogenic than S. sclerotiorum on sunflowers and a number of other hosts in greenhouse tests.

Head rot, caused by S. sclerotiorum, was found in a number of fields, but infections were light. Chilean agronomists reported that infections were much easier to find earlier in the season, before the sunflowers matured. This disease is often extremely destructive in individual fields in Chile (2).

Systemic infection of downy mildew, caused by Plasmopara halstedii (Farl.) Berl. & de Toni, was observed on a few plants in three fields. No secondary infections on leaves were seen.

Powdery mildew (Oidium sp., presumably Erysiphe cichoracearum DC.), was found on a few plants in sunflower fields and also on a few plants in the greenhouse at Santiago. Powdery mildew had not previously been reported on sunflowers in Chile.

Headdrop, a disorder common in Chile (2) and recognized in Manitoba by Señor Mario Astorga C. of Santiago, Chile, in 1951, was present in trace amounts in about half of the fields inspected. The condition appears to be due to a genetic disturbance or to a heritable susceptibility to certain environmental conditions, not yet determined, which results in abscission of the heads at full bloom (8).

Discussion

Sunflower rust, not previously known to occur in Chile, was found in 13 fields in March, 1954. The locations ranged from 90 to 850 kilometers south of Santiago. All the infections were very light; in the three most southerly locations, only one to four pustules were found after a painstaking search.

It is not known how sunflower rust became established in Chile, nor, for that matter, is it known with certainty how it reached most of the countries where it is now an important pathogen. The extensive desert in the north of Chile should be an effective barrier against spread from Peru, and the high Andes on the east should provide protection against rust from Argentina, particularly as the prevailing winds come from the Pacific Ocean on the west. Several different explanations for the occurrence of the rust may be based on the available data; all are speculative.

As all the infections found were very light, they may have developed from sparse inoculum which was introduced into Chile during the growing season of 1953-54. If this were so, rust infection might be expected to increase in intensity in future years, at least in those areas

where conditions were favorable. It was suggested that surveys be made again in 1955 and 1956 by Chilean specialists to check on this point[5] No sunflower rust was found in the survey made in 1955[6].

It may also be suggested that the infections observed came from wild hosts closely related to sunflowers. P. helianthi is known to attack many species of Helianthus in North America, and was recorded on Xanthium strumarium in Russia (1). Early herbalists thought that sunflowers came from Peru, but it is now believed that they were restricted to North America (4). Plants native to Chile described as species of Helianthus have been assigned by modern botanists to the genera Flourensia and Wedelia[7]. The fact that rust found on F. corymbosa in Chile differed from P. helianthi, and that P. helianthi did not attack seedlings of this species in greenhouse tests at Winnipeg, does not preclude the possibility that rust from other species of Flourensia or Wedelia may attack cultivated sunflowers, or that rust from sunflowers may infect the native plants and survive adverse seasons on them.

If native South American plants related to sunflowers are the usual hosts of the rust that attacks cultivated sunflowers in South America, it is reasonable to expect that differences in pathogenicity between South American and North American isolates might occur. If the related wild species are not the source of inoculum for cultivated sunflowers, but can be attacked by the rust from cultivated sunflowers, then the South American isolates might be expected to be similar in pathogenicity to rust collected in North America, where it presumably originated. Similarity of the rust in the field in South America and in Western Canada is indicated by the fact that rust-resistant sunflower selections produced in Western Canada were also resistant in Peru and Argentina (6), and also by the results of greenhouse studies at Winnipeg (9).

The extensive range of the rust suggests that, in order to spread so far, it must have been present in Chile for a number of years, but that it has barely maintained itself at a number of locations where it had gone undetected. In support of this argument, Señor Emilio Williams, extension agronomist at Talca, told the writer that he had seen appreciable infections of sunflower rust east of Talca in 1951. Señor Roberto Gonzalez Rodriguez, a student in the Faculty of Agriculture at the University of Chile, Santiago, was sure that he had seen pustules of rust on a few sunflower plants near Rancagua in 1951. It is easy for even a trained observer to confuse certain insect infestations and leaf injuries of sunflowers with rust, unless he checks the material with a good hand lens or a microscope. The fact that both informants noticed the rust in 1951 may be significant, however. Sunflower rust was first found in Peru in 1950, and in Argentina in 1952. It is possible that it was introduced into Chile at about the same time as into the other two countries, but failed to develop there to the same extent because of less favorable conditions.

Sunflowers are grown in Chile as an irrigated crop in the summer, when there is practically no rain. Many of the fields examined in the mornings during the disease survey were still wet with dew, and heavy rust infection on beans and other plant species in sunflower fields indicates that, at least in some years, conditions are favorable for rust development even during the summer season. Chilean agronomists stated, however, that dew is not common in the area. It is possible that a few pustules of rust may survive even unfavorable seasons in certain locations, on cultivated sunflowers or possibly on some closely related wild plants, and that the infection builds up during more favorable summers. If this explanation is correct, then in most years rust may not pose a serious threat to the sunflower industry in Chile, in the dry valleys where irrigation is essential. Farther south, however, in the region of Osorno, there is sufficient summer rainfall to grow crops without irrigation. If sunflower production spreads into this region, which seems suitable for it, the rust hazard may increase greatly, and may need to be met by the incorporation of rust resistance into adapted varieties.

Acknowledgments

The writer is happy to express his appreciation for the assistance and facilities provided, and the unfailing kindness shown him during his stay in Chile, by Señor Mario Astorga C., National Director of Agriculture; Mr. E. B. Hamill, Sub-Director for Agriculture, Institute of Inter-American Affairs; Señor Carlos Muñoz P., Director of Agricultural Investigations, and Señor Fernando Mujica R., Chief of the Phytopathology Section, Ministry of Agriculture; Señores Jorge Barahona Z., Sigurd Arentsen, and Mario Vallejos, who accompanied him on disease

[5] Sackston, W. E. 1954. Outline of investigations to be made on sunflower rust in Chile. Unpublished.
[6] Volosky de Hernandez, Dora. 1955. Personal communication.
[7] Munoz P., Carlos. 1954. Personal communication.

surveys; Señor Renato Gasti, general manager of the sunflower seed buyers and processors association, and his staff; and the many other associates who helped to make his work a pleasure.

Literature Cited

1. Arthur, J. C. 1934. Manual of the rusts in United States and Canada. Purdue Res. Foundation, Lafayette, Indiana. 438 pp.
2. Astorga C., Mario, and Jorge Barahona Z. 1951. El cultivo de la Maravilla. Min. Agr. Chile, Ext. Circ. 1. 20 pp.
3. Godoy, Ernesto F. 1953. Epifitia de roya del girasol in la Argentina. Min. Agr. Argentina, IDIA, May 1953: 2-8.
4. Heiser, C. B., Jr. 1951. The sunflower among the North American Indians. Proc. Amer. Philos. Soc. 95: 432-448.
5. Mujica R., Fernando, and Claudio Vergara C. 1945. Flora fungosa Chilena. Min. Agr. Chile. 199 pp.
6. Putt, Eric D., and W. E. Sackston. 1955. Rust resistance in sunflowers (Helianthus annuus L.). Nature 176: 77.
7. Rojas M., Emilio, and A. F. Swanson. 1955. Progress report development of rust resistant sunflowers. Min. Agr. Peru, Agr. Res. News Notes Vol. 2 No. 2.
8. Sackston, W. E. 1952. Sunflower diseases in Manitoba in 1951. Rep. Can. Plant Dis. Surv. 31: 36-39.
9. Sackston, W. E. 1956. Forms and races of Puccinia helianthi. (Abst.) Phytopathology 46: 25.

PLANT PATHOLOGY LABORATORY, WINNIPEG, MANITOBA, CANADA

AN UNEXPLAINED EXTENSIVE DYING OF OAK IN PENNSYLVANIA

Charles L. Fergus and Joseph E. Ibberson[1]

This preliminary report on considerable local dying and mortality of oaks of the black oak group in Pennsylvania is presented because of the large numbers of trees involved and the potential seriousness of the problem. Personal conversations with several representatives of different States, such as New York, West Virginia, and New Jersey, indicate that oaks have exhibited this dying and mortality in those States also.

District foresters of the Pennsylvania Department of Forests and Waters noted the mortality, and inspection of the areas concerned were made by many interested persons including foresters, entomologists and pathologists.

The mortality of unknown cause has been observed on red, scarlet, and some black oaks in the vicinity of Bloomsburg, Williamsport, and Renovo. Examination of annual rings of stumps of cut trees, and increment borings of standing affected trees, reveals a striking reduction of increment in the past five or more years. The stands affected are extensive and mostly of sprout origin. Trees of various ages, as well as crown class, exhibit the mortality. In some local areas, it is impossible to find a red oak not affected by the disorder.

The extent of the mortality is not exactly known, but district foresters and forest rangers have been notified of the condition by a circular letter from the Department of Forests and Waters (2), which describes the general conditions and symptoms. Through their observations, the extent of the mortality, and the number of trees affected, may be ascertained.

The initial symptoms involve the foliage. Many leaf buds fail to open, sometimes over large areas of the crown, at other times only on single branches, resulting in an apparent dieback. The leaves that do open fail to develop to normal size and the leaf blade may be aborted. Some foliage at the outer branch tips may be slightly chlorotic. Some fully formed leaves may die and turn brown, but no wilting nor defoliation occurs.

A gradual decline in vigor becomes apparent until finally the entire tree dies. The death is from the top down and from the outside to the inside of the crown. It is not known exactly when a tree dies following the initial onset of symptoms, but there is some indication that several years usually ensue. No butt or root sprouting was observed on any trees, even on those whose above-ground parts had been dead for several years judging from the amount of decortication that had occurred. Water sprouts, however, were observed on the upper bole of some of the trees. These also die in time. Groups of trees in which the various stages of the decline and death are present have been found.

Associated species such as white oak, red maple, hemlocks, white pine, and others, are not affected on the same sites.

The cause of this dying is not known, and since it is found on all types of sites and environmental conditions, there seems to be no correlation with the physical environment. The past four summers in Pennsylvania have been dry with rather marked rainfall deficits. Thus, drought may be involved. Hemlock is more susceptible to drought than is red oak (3), yet hemlocks were thriving well on these sites. Hence summer drought alone seems to be ruled out.

Superficial examination of the roots of living trees showing initial foliage symptoms revealed the presence of rhizomorphs of Armillaria mellea (Vahl.) Quel. on the outside of roots of various diameters. In several instances, rhizomorphs were found between the bark and wood of trees dead approximately two months. The fungus was usually found on trees which had been dead for longer periods of time. Examination of the roots of some unaffected white oaks on the same sites showed them to be free of rhizomorphs of A. mellea.

Cultural isolations using standard techniques have been attempted from twigs, branches, trunk and roots of affected trees. No potential pathogens were isolated. However, a much larger sampling should be taken for further study. In several instances, cankers were noted on the trunks of affected trees. Attempts to isolate Phytophthora spp. from these cankers, as well as from the soil near roots of affected trees, using the apple method of Campbell (1), failed.

The mortality, then, appears to be of unknown cause. It should be emphasized that the symptoms exhibited are quite dissimilar to those of oak wilt, caused by Endoconidiophora fagacearum Bretz. Isolations failed to yield this fungus. Further, the trees showing this decline

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1 Respectively, Associate Professor of Botany, Pennsylvania State University, and Chief, Division of Research of the Pennsylvania Department of Forests and Waters. The observations described herein were made in June and July, 1955.

are in counties in which oak wilt had not been discovered until the aerial survey of 1955 disclosed two infection spots (involving only four trees) in Clinton County. These are 50 miles away from the nearest previously known spots. The large number of trees involved, in the light of the limited spread of oak wilt, mitigates against the idea that oak wilt is involved.

Prompt cutting of trees will help to reduce the financial losses involved, but until the cause or causes of the mortality are discovered, the appropriate measures needed to avoid future losses are unknown. It is imperative that the location of affected trees be discovered and that removal of affected timber be expedited so that losses will be reduced to the minimum and that Pennsylvania's oak forests be maintained in the best possible condition. A program of research to determine the nature of the cause is necessary, with the hope that preventive measures may thus be found to avoid future losses.

Literature Cited

1. Campbell, W. A. 1949. A method of isolating Phytophthora cinnamomi directly from soil. Plant Dis. Reptr. 33: 134-135.
2. Goddard, M. K. 1955. Excessive mortality of oak in the black oak group. Pennsylvania Dept. of Forests and Waters Circ. Letter R-23. July 14.
3. McIntyre, A. C., and G. L. Schnur. 1936. Effect of drought on oak forests. Pennsylvania Agr. Exp. Sta. Bul. 325: 1-43

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, PENNSYLVANIA STATE UNIVERSITY, AND DIVISION OF RESEARCH, PENNSYLVANIA DEPARTMENT OF FORESTS AND WATERS.

OBSERVATIONS CONCERNING AUTUMN INFECTION OF OAK BY ENDOCONIDIOPHORA FAGACEARUM BRETZ [1]

W. J. Stambaugh and J. C. Nelson[2]

Detection of oak wilt (Endoconidiophora fagacearum Bretz) infection areas in Pennsylvania (3), as in many other States (2), is accomplished primarily by aerial survey during the summer months when foliar symptoms are evident. On the basis of results from wound transmission studies (1) and artificial inoculation experiments, it has been assumed that trees exhibiting wilt symptoms in the summer were invaded by the fungus during the preceding spring. Trees that are artificially inoculated in the spring usually wilt within 20 to 30 days.

Field observations[3] during the past several years have indicated that either a considerable number of trees are excessively late in symptom expression after spring invasion or infection has actually occurred during the fall months. The latter explanation is supported by evidence obtained from both routine examinations of natural infection areas in Perry County, Pennsylvania during 1955-56, and artificial inoculations in autumn.

The only visible, early symptom of autumn oak wilt infection is a premature reddening of the leaves on a few scattered branches which precedes normal fall coloration by at least two weeks. On September 12 and 15, 1955, eight trees bearing such symptoms were marked for later observation. The oak wilt fungus was isolated from three of the marked trees that failed to leaf out during the following spring. The other five trees are in full leaf and show no indications of foliar wilt to date.

A similar reaction was observed on trees artificially inoculated during the autumn of 1955. Of five trees inoculated on September 15, 1955, only one produced normal foliage the following spring (May 15). A few swollen buds were noted in the crowns of the other four but further expansion and leaf development did not occur. Water sprouts on the boles of these trees were in foliage by the end of May. Typical foliar symptoms were observed on trees inoculated during the months preceding and following the month of September. Five trees inoculated on August 16, 1955 were in a stage of 75 to 100 percent foliar wilt by September 15, 1955. Four of the five trees inoculated on October 18, 1955 were wilting on June 27, 1956.

A total of 92 oak wilt infection areas in Perry County, Pennsylvania were examined during September-October 1955 and no disease symptoms were observed at that time. The same spots were scouted again during May-June 1956. On ten of the areas, thirteen trees had failed to leaf out. Infection of these was confirmed by isolation of the oak wilt fungus.

Although late spring frosts occurred in localized areas throughout Pennsylvania, the last being on May 25, it is unlikely that frost damage had any effect in producing the symptoms discussed. In Perry County, frost damage to oaks and other tree species was confined to lower slopes and valley bottoms. Many of the fall-infected trees, especially those on the natural wilt areas, were situated in frost-free localities. However, frost damage was fairly severe on the inoculation plots and, in cases of heavy frost damage, foliar symptoms of artificially inoculated trees were delayed by two to three weeks.

Comparison of symptom expression by trees artificially inoculated in September and by naturally infected trees offers strong evidence that autumn infection by the oak wilt fungus does occur in nature. Such infections are characterized by an almost total lack of foliar symptoms. Although premature leaf reddening may occur, it is not recommended as a reliable symptom for field diagnosis, since it is almost identical and sometimes coincident with normal fall coloration.

Since foliar symptoms are the basis for effective aerial detection of oak wilt, fall-infected trees that fail to leaf out the following spring may constitute a special problem in survey and control of the disease. If the condition of fall oak wilt in Perry County, Pennsylvania during 1955-56 is a true indicator of the general disease situation throughout its known range, it may be necessary to alter or intensify our present methods of oak wilt survey.

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1 Contribution No. 214 of the Department of Botany and Plant Pathology, Pennsylvania Agricultural Experiment Station.

2 Instructor, Department of Botany and Plant Pathology and Research Forester, Pennsylvania Department of Forests and Waters.

3 Appreciation is hereby expressed to Dr. F. C. Craighead, Consultant, Pennsylvania Department of Agriculture, for his many contributions of data and advice.

Literature Cited:

1. Craighead, F. C., C. L. Morris, and J. C. Nelson. 1953. A preliminary note on the susceptibility of wounded oaks to natural infection by the oak wilt fungus. Plant Dis. Reptr. 39: 483-484.
2. Fowler, M. E. 1952. Aircraft scouting for pole blight and oak wilt. Jour. For. 50: 191-195.
3. Jeffery, A. R. 1955. Oak wilt in Pennsylvania -- a summary of the survey and control program for 1955. Mimeo. report. 20 pp.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PENNSYLVANIA, AND PENNSYLVANIA DEPARTMENT OF FORESTS AND WATERS, HARRISBURG, PENNSYLVANIA.

AN UNUSUAL CONE FASCICULATION OF TABLE MOUNTAIN PINE [1]

Charles L. Fergus

Because of the remarkable symptom of extreme fasciculation of cones of Table Mountain pine, Pinus pungens Lambert, and since there are no photographic records available of similar specimens, a photograph and a brief description of one is presented here. Unfortunately, the exact date and place of collection of the specimen is unknown. In has been in the Forest Pathology Specimen Collection of the Pennsylvania State University for twenty years.

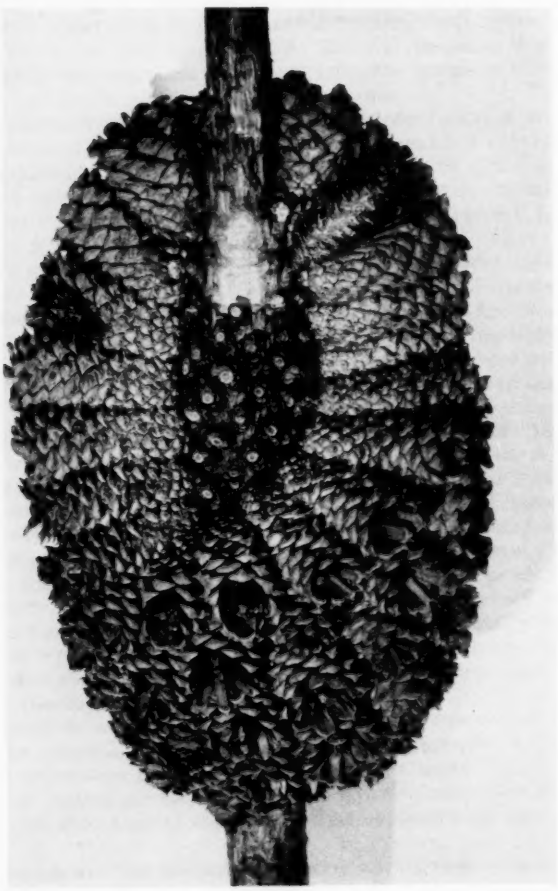


FIGURE 2. A portion of the cones removed to illustrate the spiral arrangement of the cones, and the compression of cones.

[1] Contribution No. 211 from the Department of Botany and Plant Pathology, Pennsylvania State University.

FIGURE 1. Cone fasciculation of Table Mountain pine.

A survey of the literature reveals no report of a comparable condition of pine except for that of Sorauer (2). However, the sketch he presented indicates that the fasciculation was not so dense as that described herein (Figure 1). His sketch is of Scotch pine.

Normally Table Mountain pine produces staminate flowers in long, loose clusters at the base of the growth of the season in April and May. The cones are borne in whorls of two to five, or even more, persisting for a long time, even after shedding seeds. A branch seven years old, according to Illick (1), 1 1/2 inches thick at the thickest end, and 3 1/2 feet long, bore 36 cones.

The fasciculation presented in Figure 1 was 10 inches long and 6 inches thick through the broadest portion. It bore approximately 100 cones, spirally arranged. The branch that bore the fasciculation was not noticeably enlarged and was 1 inch thick. Compression of one cone against another did not allow complete opening of the cone scales (Figure 2). In addition, the cones failed to attain normal size, being 1 to 2 inches long, instead of the normal 3 to 4 inches. Seed was produced, but unfortunately its germinability was not determined at the time of collection. Sorauer (2) reported that the cones remained smaller than normal, but bore seeds capable of germination.

The possible cause of such a hypertrophy remains unknown although Sorauer (2) believed it to be due to a local excess of concentrated, plastic food material and suggested that pistillate flowers were produced instead of staminate flowers. He cited a report of Borggreve as further corroborative evidence. Borggreve found that the terminal shoots of several 15-year-old spruces, a year after transplanting, had been transformed into pistillate inflorescences.

Literature Cited

1. Illick, J. S. 1915. Pennsylvania trees. Pennsylvania Dept. of For. Bul. 11. p. 73.
2. Sorauer, P. 1914. Manual of Plant Diseases. Volume 1. Non-parasitic diseases. 3rd Ed. (Translated by F. Dorrance) p. 373.

THE DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PENNSYLVANIA.

USE OF HYPODERMIC SYRINGE AND NEEDLE AS AN ATOMIZER

P. M. Miller

Application of small amounts of a liquid as a fine mist or spray is sometimes necessary or desirable in locations where compressed air is not available. In such cases atomizers using a rubber bulb are commonly used. This type of atomizer is tiring to use for any length of time; is difficult to aim; must be refilled often -- a process requiring partial disassembly of the atomizer; and the amount of liquid applied at any one time cannot be determined accurately without measuring it prior to its addition to the atomizer reservoir. Also these atomizers are hard to clean if they become clogged during use and they are bulky to carry into the field or greenhouse.

A very satisfactory atomizer can be made by bending the tip of a steel hypodermic syringe needle at a right angle so that it forms a striking plate. The liquid stream emerging from the needle hits the bent tip and forms a spray or mist. The fineness of the mist increases with the pressure on the hypodermic syringe. Some filing of the tip may be necessary to get just the type of spray needed, but a flat, V-shaped spray is very easy to obtain. The most convenient equipment for average use is a #23 needle used with a 5 or 10 ml syringe. The optimum size of the syringe increases as a larger needle is used, but too large a syringe for each size needle is tiring to use and will not produce sufficient pressure at the needle orifice to give a good mist. The amount of liquid applied can easily be measured and regulated since the syringes are graduated for this purpose. A Cornwall Luer-Lok 2-way valve - mady by Becton, Dickinson, and Company, Rutherford, New Jersey -- placed between the needle and the syringe, will enable repeated and fast refilling of the syringe from a reserve supply of liquid in a bottle. This is accomplished by merely pulling out the plunger of the syringe and provides a minimum of interference with the spraying. Clogged needles can usually be cleared by merely drawing a little water through them or by running a small wire through the orifice of the needle. The syringe-atomizer can be held with one hand. The other hand proved very useful in holding twigs and shoots while they were being sprayed with the atomizer during work on fire blight of pears and black knot of plums.

DEPARTMENT OF PLANT PATHOLOGY AND BOTANY
THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONNECTICUT

UNUSUAL RECORDS AND OTHER BRIEF NOTES

POWDERY MILDEW ON PEPPER IN FLORIDA

By W. D. Moore

During the spring of 1955 powdery mildew was observed on a small planting of pepper (Capsicum) near Boca Raton, Florida. At about the same time in 1956 it was again found on the same farm and was also observed on several adjacent farms. Initial infections were typical, occuring as minute white powdery spots on the lower leaves and spreading rapidly to cover the entire leaf surface. In advanced stages considerable defoliation followed the heaviest infections with a consequent reduction in yields and quality of fruit.

The organism causing this infection has been identified by John A. Stevenson of the Plant Disease Epidemics and Identification Section, United States Department of Agriculture, as being Erysiphe cichoracearum DC. He also reports that, although there have been many reports of powdery mildew on Capsicum throughout the tropical regions of the world, none have been reported for the United States. Also, Mr. Erdman West of the Florida Agricultural Experiment Station, Gainesville, Florida, states that available records fail to show any previous appearances of this disease in Florida. From these reports, it appears that the present outbreak is the first instance of powdery mildew on pepper in the United States.

AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE
FT. LAUDERDALE, FLORIDA

STATUS OF DUTCH ELM DISEASE IN KNOX COUNTY, TENNESSEE

By H. E. Reed and H. L. Bruer

A recent survey conducted by the Tennessee Department of Agriculture in conjunction with the Plant Pathology Department of the University of Tennessee Agricultural Experiment Station has revealed the widespread occurrence of Dutch elm disease in Knox County.

The Dutch elm fungus, Ceratostomella ulmi Buis., was isolated from 20 of the approximately 125 sick elm trees examined in the area.

Ten other elm trees on the University of Tennessee Campus at Knoxville have been found to have Dutch elm disease since it was first found in the area in September, 1955. [1]

Several other elm trees are showing typical wilt symptoms on the Campus and it appears that the disease is becoming serious in the entire Knoxville area. Control measures recommended by the United States Department of Agriculture[2] have been in operation on the University Campus since March, 1956.

TENNESSEE DEPARTMENT OF AGRICULTURE AND UNIVERSITY OF TENNESSEE

1 Reed, H. E. 1955. Occurrence of Dutch elm disease in Tennessee. Plant Dis. Reptr. 39: 882.
2 Anonymous. 1952. Control of Dutch elm disease and elm phloem necrosis. U. S. Department of Agriculture Leaflet No. 329.

CURVULARIA BLIGHT OF OPHIOGLOSSUM IN OHIO

By C. W. Ellett

A leaf blight of adder's-tongue fern (Ophioglossum vulgatum L.) was collected by G. W. Blaydes in May, 1955 in Franklin County, Ohio. The cause of the blight was determined as Curvularia crepini (Westend.) Boedijn. Diseased plants were found frequently during May and June 1956 in University woods. Any part of the foliage leaf or of the sporophyll may be affected. Blighted areas are gray at first and then black due to the growth of conidia and conidiophores.

This is the first report of this fungus in North America and apparently the first report of any disease on the host in this country. The fungus has been reported from Europe and a complete description of it is given by Ellis et al. [1]

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, THE OHIO STATE UNIVERSITY, COLUMBUS 10, OHIO

1 Ellis, M. B., E. A. Ellis, and J. Pamela Ellis. 1951. British marsh and fen fungi. I. Trans. Brit. Mycol. Soc. 34: 147-169.

ANNOUNCEMENT:

PLANS FOR FIFTIETH ANNIVERSARY OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

Glenn S. Pound, Secretary, American Phytopathological Society, writes that the 50th Anniversary Committee has been set up, as follows:

W. M. Bever	G. S. Pound, Chairman
D. E. Ellis	H. A. Rodenhiser
J. G. Harrar	J. R. Shay
W. B. Hewitt	R. H. Wellman
C. S. Holton	

Tentative plans are for two or three days of very significant symposia with speakers from all over the world. The Program Committee invites suggestions of any nature, especially as to themes for symposia, and specific topics and speakers.

Additional announcements will be made from time to time.

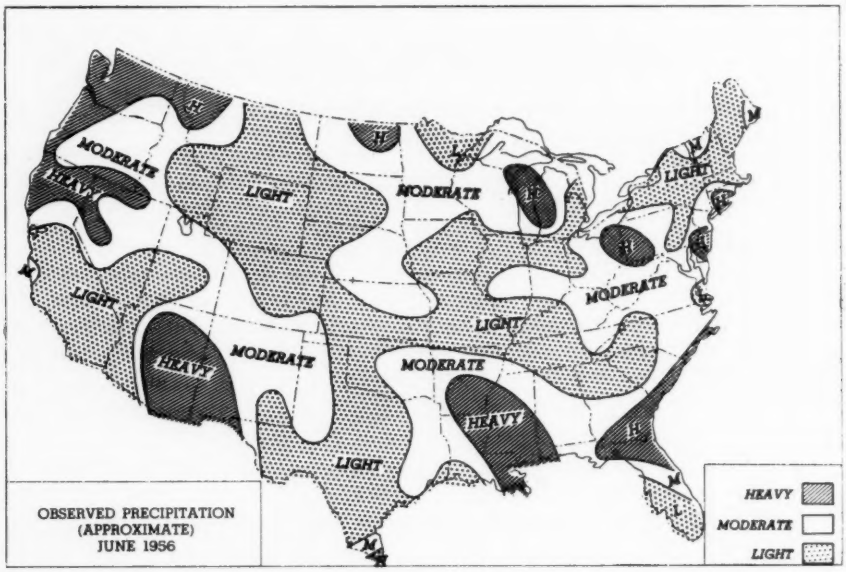
SOME CORRECTIONS

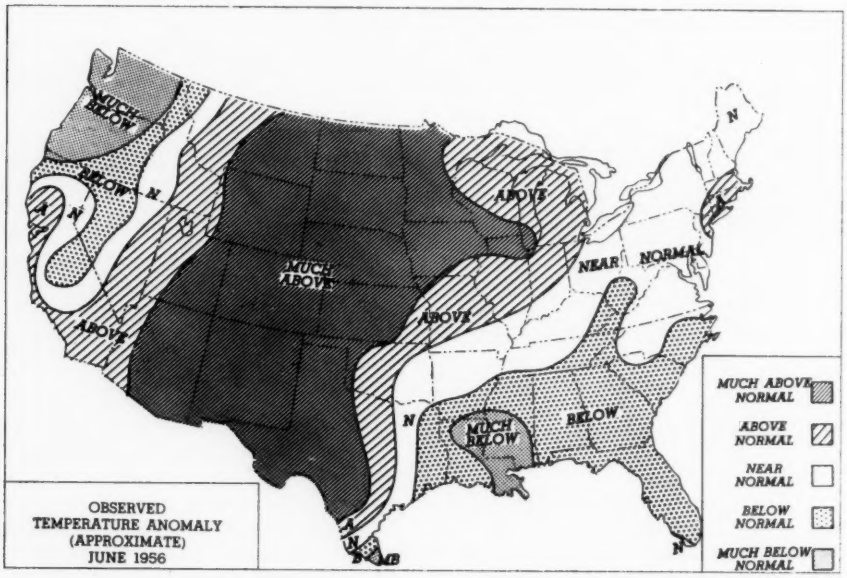
SUPPLEMENT 238, "Development and Production of Pathogen Free Propagative Material of Ornamental Plants":

page 71, Reference 4, line 3 -- read Unpubl. for Unpbl.
page 85, paragraph 3, line 2 -- observations instead of observatoins.
page 88, paragraph 4, line 4 -- pathogen-free stock, not pathogen-stock.
page 89, paragraph 2, next to last line, read "removed to reduce invasion" (take out extra to reduce).

REPORTER, July 15, article by Leopoldo Abrego et al., in list on page 659:

Last entry under café, name should be Omphalia flavida, not florida.
Under henequén, the second species should be Agave letoriae, not latoriae.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.